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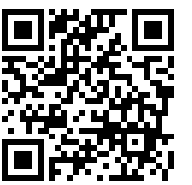

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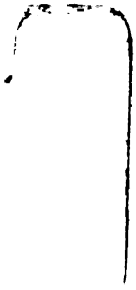

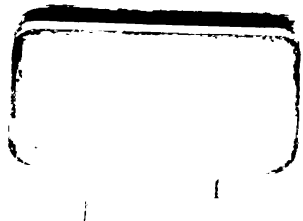

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Mechanicalization of the Army . . . . Captain H. P. W. Hutson 1
The Influence of Intelligence upon the Tannenburg Campaign
Brevet-Major B. C. Dening 35
The 20th (Field) Company, Royal Bombay Sappers and Miners, 1914-18
Major H. W. R. Hamilton 41
Divisional Engineers of the Future—their Duties and Equipment
Major-General G. Walker 63
The Disembarkation at Alhucemas Bay . Lieut.-Colonel R. E. M. Russsell 68
Waziri Ways . . . . . Brigadier-General H. H. Austin 75
Battle Honours of Royal Engineer Units 87
An Unofficial History of the Signal Service with the British Salonika Force, 1915-18 . . . . . Captain C. C. S. White 97
M. G. O. E. . . . . Colonel D. M. F. Hoysted 109
The Coal Problem and Low Temperature Distillation . . . . .
Captain G. MacLeod Ross 117
The Stereoscopic Examination of Air Photographs . Lieut. M. Hotine 125
"Ilex" in the Ocean Race . . . . . By one of the Crew 145
Memoir. Major-General Beresford Lovett 155
Books. Magazines. Correspondence 157

VOL. XLI. No. 1. MARCH 1927.

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CONTENTS.

		PAGE
1	COOPER'S HILL WAR MEMORIAL PRIZE ESSAY, 1926. MECHANICALIZATION OF THE ARMY. By Captain H. P. W. Hutson, D.S.O., O.B.E., M.C., R.E.	1
2	THE INFLUENCE OF INTELLIGENCE UPON THE TANNENBERG CAMPAIGN. By Brev.-Major B. C. Dening, M.C., *p.s.c.*, R.E.	35
3.	HISTORY OF THE 20TH (FIELD) COMPANY, ROYAL BOMBAY SAPPERS AND MINERS. (*With Maps*) (*concluded*). By Major H. W. R. Hamilton, D.S.O., M.C., R.E.	41
4.	DIVISIONAL ENGINEERS OF THE FUTURE—THEIR DUTIES AND EQUIPMENT. By Maj.-Genl. G. Walker, C.B., C.B.E., D.S.O.	63
5.	THE DISEMBARKATION AT ALHUCEMAS BAY. (*With Map.*) By Lt.-Col. R. E. M. Russell, C.B.E., D.S.O., R.E.	68
6.	WAZIRI WAYS. (*With Map.*) By Brigr.-Genl. H. H. Austin, C.B., C.M.G., D.S.O.	75
7.	BATTLE HONOURS OF ROYAL ENGINEER UNITS (*continued*)	87
8.	AN UNOFFICIAL HISTORY OF THE SIGNAL SERVICE WITH THE BRITISH SALONIKA FORCE, 1915-18 (*concluded*). (*With Maps and Plates.*) By Captain C. C. S. White, M.B.E., R.E.	97
9.	M.G.O.E.—TECHNICAL EXAMINATION BRANCH FOR R.E. SERVICES. ITS INCEPTION, HISTORY AND FUNCTIONS. By Colonel D. M. F. Hoysted, D.S.O.	109
10.	THE COAL PROBLEM AND LOW TEMPERATURE DISTILLATION. By Captain G. MacLeod Ross, M.C., M.ENG., A.M.INST.C.E., R.E. ..	117
11.	THE STEREOSCOPIC EXAMINATION OF AIR PHOTOGRAPHS. (*With Plates.*) By Lieut. M. Hotine, R.E.	125
12.	"ILEX" IN THE OCEAN RACE. (*With Photograph.*) By one of the Crew	149
13.	MEMOIR .. .. Major General Beresford Lovett, C.B., C.S.I.	155
14.	BOOKS	157

Work of the R.E. in the European War, 1914-19. Miscellaneous. (Compiled by Colonel G. H. Addison, C.M.G., D.S.O., M.A., M.I.MECH.E.) Brigr.-Genl. Magnus Mowat, C.B.E., T.D.

Lés Opérations en Macédoine L'Epopée de Doiran, 1915-1918. (By Lt.-Colonel Nédeff, General Staff Bulgarian Army.) G.W.

National Frontiers in Relation to International Law. (By Colonnello Vittorio Adami, Historical Section, General Staff, Rome, 1919.) Colonel Sir C. F. Close, K.B.E., C.B., C.M.G., F.R.S.

The Magnetic Survey of India, 1901-20. Dr. Charles Chree, SC.D., LL.D., F.R.S.

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involved it is essential that we understand the principles which govern the employment of engineers in the field.

These two points, therefore—the probable course of mechanicalization and the function of engineers with an army—will be considered now before we attempt a more detailed treatment of our subject.

THE PROCESS OF MECHANICALIZING THE ARMY.

Inevitability of the change.—The British Expeditionary Force entered the Great War equipped with a small proportion of lorries, some touring cars and a few motor bicycles. By the autumn of 1918 our troops possessed no less than 118,000 petrol-driven vehicles. Mechanicalization in the form of tanks, lorries and motor 'buses had been called upon to improve the mobility of the army. The cessation of hostilities brought the usual period of retrenchment. Mechanicalization, in common with other processes applicable to warfare, was slowed down. But there can be no question of its stopping. Movement in all its forms is the crucial problem of the day, and mechanicalization is the solution that science offers us. The reorganization of the army on a mechanical basis, therefore, is generally accepted as inevitable.

Efficiency must not suffer during the process.—Yet, whilst there can be few persons who do not see the necessity for mechanicalizing the army, a considerable difference of opinion exists as to how this is to be done. In particular, very different views are held concerning the rate at which the transformation should take place.

However much we dislike the prospect of another war, the contingency is one that has to be faced. France is still fighting in Morocco and Palestine, and there were times during the Chanak affair and the Mosul boundary dispute when war seemed rather more of a probability than a possibility for our own country. So long as universal disarmament remains beyond the pale of practical politics it is obvious that we must be prepared for war.

Mechanicalization, using the word in its widest sense to include both weapons and means of movement, has lessened the time for such preparation. Once hostilities have been decided upon, the onset may be made with a rapidity and power hitherto unknown. The importance of seizing the initiative at the beginning of a campaign has become, therefore, more vital than ever. This means that such forces as we maintain must be kept in constant readiness for war. Hence we cannot risk being caught in the process of a change. Our mechanicalization must be carried out in such a manner that the fighting efficiency of the army is at no time impaired.

Dangers of too rapid Mechanicalization.—Continuous efficiency then, is an essential of any scheme for mechanicalization, whether it entails as rapid a progress as possible, or proceeds step by step, trying out each move before advancing further Subject to this

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proviso, however, the choice of policy is clearly open to argument. Those who urge a rapid transformation look mainly to the experiences of the Great War, envisaging campaigns in developed rather than in undeveloped countries. Their object is a major war against an opponent organized similarly to themselves. From this standpoint there is much to be said for their claim. But there are other factors to be taken into account. We cannot ignore the financial side of the problem. Wholesale mechanicalization would entail an initial expenditure quite out of the question in the present depleted state of the country's exchequer. Again, although progress in the design of mechanical vehicles has advanced rapidly, we are still far from being able to state that any of the existing types fully satisfy military requirements. Perhaps it is not too much to say that the army has yet to decide exactly what it wants. Under such conditions a too rapid mechanicalization might not only lead to a great waste of public money, but would conceivably leave the army inferior to an enemy who had waited to adopt a later type of vehicle. Finally, it must not be forgotten that, although our training is directed ostensibly towards a major war, we are equally likely to find ourselves engaged in an expedition against a semi-civilised people or in a terrain unsuited for mechanical vehicles as we know them to-day. It would be unsound, therefore, to mechanicalize the whole army until either the conduct of small wars and Imperial police duties had been otherwise provided for, or until a form of mechanicalization had been evolved adapted to such operations. We may conclude in consequence that any wholesale and rapid mechanicalization of the army is impracticable, at any rate at the present.

Equally essential not to lag behind.—Nevertheless, whilst we regard a too rapid transformation as folly, undervaluation of the potentialities of mechanicalization is equally dangerous. The late war furnished an inkling of what it might achieve, and at least one great continental power has taken the lesson to heart. We cannot afford to lag behind. Mechanicalization is not a process to be carried out at a moment's notice. It involves considerable dependence upon factories and, consequently, close co-operation with and organization of industrial resources. Hasty improvisation at the eleventh hour is impossible. To attempt it is to run the risk of being surprised, and surprise in material and organization is the most far-reaching of all.

Judicious progress needed.—Plans for mechanicalization, therefore, must steer a judicious middle course. There ought to be no sweeping change until we are certain that it will be for the good, and that the scrapping of the old organization and the substitution of a new one will bring greater fighting efficiency. At the same time every possible effort must be made by research and experiment to discover and try out new designs and processes. Whilst recognising the

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between any of these. The army has already entered upon the first, and at the same time is experimenting with a view to the second. Overlapping must occur. Nevertheless, for convenience of discussion it is proposed to treat the phases separately. The experiences of the Great War and the results of subsequent exercises and trials provide material for consideration of the first stage. There are less data for the second, and we shall have to rely upon conjecture based on the latest mechanical developments. These two periods, however, represent practical politics so far as the present generation is concerned, and will, therefore, be dealt with in some detail. The third and final stage is largely a matter of speculation, calling for the vision of those mechanical clairvoyants whom Colonel Fuller sees composing the General Staff of future armies. It is not proposed to deal at length with this phase, and conjecture will be confined to such developments as are indicated by recent scientific research.

In discussing each stage we shall consider first mechanicalization and the army, to show its probable course and the influences it may be expected to have upon warfare. We shall then examine the position of the engineers under the new conditions and see what changes may be necessary to meet them.

1. THE FIRST STAGE—IMPROVISED MECHANICALIZATION

IMPROVISED MECHANICALIZATION AND THE ARMY.

Beginning of Mechanicalization.—The mechanical era as applied to warfare may fairly be said to have seen its birth in the Great War. Not that this was the first time that mechanical devices were employed as an aid to fighting. Far from it. The horse-drawn chariot of the Assyrians at Lagash, 3000 years B.C., has been hailed as the prototype of the modern tank (1) and it is said that the Persian king Artaxerxes, fighting his rebellious brother at Cunaxa, adopted what were virtually tank tactics with his scythe-armed chariots.(2) The catapults of the tenth century and the culverins of the sixteenth were as much mechanical products of their age as the 15-inch howitzer is of modern times. But to describe these early efforts as mechanicalization is going too far, and weapons, mechanical devices though they are undoubtedly, do not fall within the term as we are considering it here. It is mechanicalization as it effects movements that we have to deal with now. And prior to 1914 armies marched or rode into battle, and their supplies and munitions were carried by horse-drawn vehicles. There have been railways, of course, for nearly a century, available for strategic moves, and to a limited extent, for tactical ones. But their real function has been to maintain a force from its base, and we may say that the army continued to carry itself into the fight.

(1). "Tanks in the Great War" (Fuller), p. 300.
(2). "Warfare" (Spaulding), p. 68.

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It did so in 1500 B.C., when Thotmes III, marching rapidly from Zalu, on what is now the Suez Canal, across the desert, reached Gaza, a distance of 160 miles in twelve days.(3) And again in the Mons to Marne retreat, when five divisions and one cavalry division covered 200 miles in thirteen days. Evidently mobility has not kept pace with other improvements in war. So long as man and horse supplied the motive power the speed of an army was limited to approximately fifteen miles a day. It was the advent, in 1914, of the petrol-driven vehicle to the battlefield that made greater mobility possible.

Progress during the Great War.—The enormous increase that took place during the four years 1914-1918 in the number of motor vehicles with the forces in France is largely attributable to the fact that operations were being carried on in a country well equipped with roads, and to the absolute necessity for relieving congestion on the railways. But, although mechanical transport was used extensively, its advantages were never exploited to the full. Incidents such as Gallieni's taxicab reinforcement of Maunoury, when he was engaged with Von Kluck in September, 1914, the transport of infantry in lorries to support the mounted troops during the "Race to the Sea" in the same year, and the move of the First American Army, 400,000 strong, in six nights from the St. Mihiel region to the Argonne, in September, 1918, showed something of its potential value. And the arrival of the tank, the armoured cross-country vehicle created as the answer to machine gun nests, trenches and barbed wire, opened a still larger vista of possibilities. The middle of a campaign, however, is no season for far-reaching changes in organization and equipment. So the problem of mechanicalization was left for solution after the war.

Problem confronting the Army to-day.—Two factors are contained in the problem that now faces us—fire-power and movement. The Great War brought a considerable measure of achievement of the first, and despite the fact, or possibly because of it, that during some three-and-a-half years its fighting was mainly of a static nature, it impressed upon us the need for the second. The essence of its teachings was that a force should be both hard-hitting and fast-moving. Fire-power and movement had to be combined. Either one without the other was valueless. The efficient combination of these two factors, then, is the problem before the army. The mechanically-propelled vehicle provides the means, and the experiences of the Great War give a clue as to the way.

Of the nations who took part in that struggle France, perhaps, has made the greatest subsequent progress in mechanicalization. This is mainly due to her military position with reference to Germany. Attack across the frontier by this neighbour is a

(3). "Warfare" (Spaulding), p. 11.

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mobility. Fast-moving columns, at first up to, say, brigade group strength, ultimately of whole divisions, could be formed, and would be able to operate at about six miles per hour over a radius of some hundred miles. Rapid moves from one portion of the battlefield to another, or from front to rear, at six to eight miles an hour could be made by large or small bodies of infantry supported where necessary by mechanicalised artillery, tanks and armoured cars. Mounted formations could be strengthened in fire power with no loss of mobility by the addition of " mechanicalised " formations.

The full effects of this mechanicalization must be largely a matter of conjecture. But we shall be justified in making certain assumptions as to the general characteristics of any fighting that may occur during this stage ;—

(*a*) Cavalry will still be required for reconnaissance. Their offensive power and, therefore, the scope of their activities may be increased by organizing them on the lines of the French " Divisions légères."

(*b*) Mobile columns are likely to be employed to seize places of tactical importance in advance of the rest of the force, or may be rushed up to exploit a success or close a gap. They will certainly be used in rearguard operations.

(*c*) The importance of communications to a force will be greater than ever, whilst at the same time mechanicalization has increased the means of interrupting them.

(*d*) There will be a tendency for fighting to be attracted to areas unsuited to mechanical movement. Such localities will appeal to the defence by reason of the security they offer against attack by mechanicalized columns. The attacks will be drawn towards them to forestall the enemy and so deny him the advantages they afford.

(*e*) Blows will be struck and parried at greater speed, with a relatively greater strength and over a wider area than heretofore. Phases of battle, therefore, may be expected to change more rapidly and more abruptly than in the past.

IMPROVISED MECHANICALIZATION AND THE ENGINEERS.

Engineers in 1914 *and to-day.*—Having considered the course mechanicalization is likely to take and its probable influence upon tactics, we are now in a position to study its effects upon the divisional and corps engineers. To properly gauge the changes involved by the new conditions, however, we will begin with a glance at their position in the pre-mechanical era.

The R.E. entered the 1914-1918 struggle with an organization based largely upon the teachings of the South African war. They were intended to move dismounted or mounted acco rding as they belonged to an infantry or a cavalry division. Their chief duties were to provide for the passage of these troops with their transport

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across rivers, streams and other obstacles, to render difficult by demolition or otherwise the movement of the enemy, to carry out such works as were necessary to strengthen positions to be held, or to destroy by mining those of the foe, and to arrange such temporary accommodation, water supply services, etc., as might be needed. This was a formidable array of tasks, and there were others which there is no space to detail.

To carry them out there were at first only two field companies per division. It was not long before this number had to be increased by the addition of a third company. But even so the engineering personnel proved inadequate, and pioneer battalions were organized to supplement them. However, the vastly increased firepower of the contending armies, combined with the generally intensive nature of the fighting, so increased the quantity of field works required, and widened their scope to such an extent, that it became clear that the major portion of at any rate the front line work would have to be undertaken by the infantry. The numbers of engineers were sufficient only for those tasks which demanded technical skill, special tools, or particularly elaborate organization in connection with the main zone or rear defences in position warfare.

Besides the question of field works there was the problem of bridging. Each field company carried enough pontoons and trestles to construct 75 feet of medium bridge. The bridging train, which was an army unit, had material for 250 yards of medium, or 125 yards of heavy, bridge. This so-called heavy bridge would carry such mechanical transport as the expeditionary force was equipped with at first, but was far too weak for the loads that arrived subsequently. In October, 1914, there was the eight-inch howitzer weighing thirteen tons on one axle. It was followed shortly by by the six-inch Mark VII gun on a naval mounting with a maximum axle load of seventeen tons, and during 1917 the introduction of tanks brought the weight to be carried up to thirty tons. Loads such as these demanded special bridging material. The army possessed neither the equipment nor the personnel trained in its use. A good deal of rapid railway bridging had been done in South Africa, but under very different conditions, and heavy timber and trestle bridging, in which the engineers received some training in peace, was too slow a method for modern conditions. Though the need for heavy bridging first arose on the Aisne, there was comparatively little of this work necessary during the subsequent period of static warfare. This gave time for steel spans to be obtained and for a certain amount of training to be given in their erection. From 1917 onwards, bridging became of great importance, and the power of the British Army to advance depended largely on the speed with which its engineers could construct bridge crossings. The field companies erected temporary crossings for the infantry in the

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first instance, and followed these with medium bridges for their first line transport. Then the heavy bridges were put up, mainly by fortress companies which had been converted into army troops companies and equipped with special plant and mechanical transport for the purpose. A most noticeable point was the short interval of time after the first temporary crossing before the heavy bridge was wanted.

After the war the divisional engineers were reorganized as they stand today, *i.e.*:—

H.Q.
Field Park Company
3 Field Companies

There are no corps engineers shewn as such in the new war establishments (1) but they would presumably be found by the allotment of one or more of the non-divisional units, possibly an army troops company and a bridging park. The field companies do not differ greatly from those of 1914. They are slightly stronger in personnel, and some minor changes have been made in their transport, but generally speaking, they remain much as they were except, of course, for the fact that they now carry no bridging material. During the war most of the companies dumped their pontoons and trestles in divisional or corps parks, partly because the transport of this equipment was a hindrance to them, and partly because they needed the waggons for other purposes. The withdrawal of the bridging equipment then, is merely the acceptance of what had become a recognised practice. The field park company is primarily a workship unit, existing at present in cadre form only. It is to carry two trestles and three 21-ft. bays of superstructure for a medium bridge.

The bulk of the bridging material is apparently to be concentrated in parks, presumably army units, which will be alloted to formations as circumstances demand. Broadly speaking, there are three types of bridge to be considered:—(1) assault bridges; (2) floating bridges; (3) steel bridges. The light or assault bridges carry infantry or pack. No details of their transport nor of the scale on which they are to be provided are available as yet. It is possible that they will be carried in a corps or divisional park and issued to units or formations for specific operations. A suitable scale of provision might be nine bridges, each eighty feet long, per division. As regards floating bridges, it is believed that three medium bridges, each 126 feet, and four heavy bridges of 105 feet, are to be carried in a pontoon park. Finally, there will be a bridging park for steel spans. These two last units, the latter of which already exists on paper, will be under army control, probably, and will be detached temporarily to lower formations.

(1). "Provisional War Establishments" XXVa.

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Their employment under the new conditions.—The chief characteristics of warfare under the conditions of improvised mechanicalization have been dealt with in a preceding paragraph. They will affect field engineering in two ways :—

(1) By decreasing the time factor, *i.e.*, they demand work at an increased speed.

(2) By increasing the importance of communications, so that the question of their maintenance, including bridging, of course, has become the most urgent duty of the engineers.

Engineers will be required with the mobile columns, as well as with those portions of the force which have not been mechanicalized. Their duties with the former will include :—

(*a*) Passage of troops and transport, including tanks, over gaps and obstacles.

(*b*) Creation of gaps and obstacles to destroy the enemy's mobility.

(*c*) Maintenance of roads required by their own forces and destruction of those wanted by the opposing troops.

(*d*) Rapid fortification, with particular attention to the construction of obstacles to meet attack by tanks and armoured vehicles.

Engineers working with unmechanicalized formations will find their tasks much as they have been hitherto, but under conditions which demand greater rapidity of work with, at the same time, a higher degree of solidarity and strength to meet the more destructive power of modern weapons and to carry the heavier loads by which armies are now accompanied.

Changes in organization to meet these.—If the engineers are to be able to co-operate efficiently under the new conditions with the troops they are working with, they must have :—

(*a*) An organization conformable with that of the formations to which they belong, sufficiently flexible to facilitate the provision of detachments for small or dispersed tasks, and to permit concentration of effort for a work of magnitude.

(*b*) A form of transport such that personnel, tools and material can reach the site of the work in time to carry it out.

(*c*) Personnel and equipment suitable for the execution of the duties at the necessary speed and with the requisite degree of strength or elaboration.

We will examine each of these essentials separately.

Organization :–The principle of economy of force is as applicable to field engineering as it is to fighting. It implies the employment of engineers in minimum numbers until the task is disclosed, and then a rapid building up of the resources required so that the work may completed without delay. In other words, engineers, in common with the other branches of the service, have to be employed in depth.

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Their organization, therefore, must be such as will permit this.

The task of divisional engineers may be a simple demolition that could be carried out by three or four sappers or, equally well, the erection of a bridge necessitating all the engineer labour available. Obviously it would be unsound to keep the engineers fully concentrated. If this were the practice they would have to move either near the head of the advance, thus being liable to serious losses before they had started their work, and, moreover, impeding the movements of the fighting troops, or in rear, from which position it might be difficult to send them forward in time to carry out their task without checking the progress of the force. Neither alternative is desirable. The efficient execution of field engineering requires a steady building up of resources without overcrowding, and a continuous flow of work towards the desired end. Put into practice, this means engineer reconnaissance parties with the advanced troops to discover requirements and to estimate resources needed, and small detachments near the heads of leading formations ready to start the work and to elaborate the reports of the reconnoitring parties. The major portions of the engineers will move further to the rear of the force, but so that they can be sent forward as and when required. Finally, there are the workshop units, bridging trains, etc., the occasions for the employment of which it will usually be possible to anticipate, so that their dispositions may be arranged accordingly.

The present organization of the divisional engineers into H.Q., Field Park Company and 3 Field Companies facilitates observance of the principle of economy of force. It is flexible enough to give the required dispersion whilst readily providing for concentration when needed. An example may make this point clearer. Take the case of a division moving with a brigade acting as advance guard. The engineers with the force could be disposed as follows :—

With the Advance Guard mounted troops, 1 officer and 3 men (reconnaisance party).

With the Vanguard mounted troops, one section Fd. Coy., R.E., (for small tasks or to start larger ones.)

With the Main Guard mounted troops, Fd. Coy., R.E. (less one section and reconnaissance party).

With the Main Body mounted troops, H.Q. Divisional Engineers, Fd. Park Coy., two Fd. Coys. R.E.

It will be noticed that the engineers have been distributed in increasing strength from front to rear of the division. Their resources are brought into play, therefore, in accordance with the magnitude of the task. A minor work involves no waste of energy or needless exposure of personnel, since the forward detachments are on the spot to deal with it. At the same time, for a heavy task the engineer-

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ing strength can be built up rapidly, and each detachment, even the smallest, will make a definite contribution towards its completion.

As things are, the present organization of the divisional engineers is probably as satisfactory an arrangement as can be reached. Mechanicalization has not changed the divisional organization. No modification of that of the engineers would seem necessary, therefore, on this account.

Transport.–We will turn now to the question of the mobility of the engineers. The latter must be able to accompany the troops for whom they are working, and at the same time their transport must be arranged so that the flexibility within the unit is not diminished. The division in its state of improvised mechanicalization has been equipped with tractor-drawn artillery and transport. The infantry will still be on foot normally, though portions and, occasionally, perhaps, all of them may be moved in lorries or form part of a mobile column. Consequently the transportation scheme of the engineers must provide as a minimum for the mechanicalization of their first line transport, and for the movement by lorry of those portions or units which are acting with mobile columns.

It is a matter for consideration, however, whether the engineers should conform exactly with the infantry at this stage, or whether it would not be preferable to eliminate all marching personnel at the outset. The engineers are not primarily fighting troops. Their *raison d'être* is work, and there is small doubt but that a greater output of this can be obtained from men who are carried to their task, and so reach it comparatively fresh, than from those who have borne the fatigue of a long march before beginning their labours. Moreover, though in the past field engineering has been more closely connected with the infantry than with any other arm, this association is likely to become less marked in the future. We have seen already how practically all the front line field works have devolved on the infantry, whilst the engineers are employed on the more technical duties of bridging, demolition, and in connection with the more elaborate rearward services. It appears, too, that the infantry will have to accept chief responsibility for assault bridging. They may receive the material for this from the engineers, but the latter's most important concern will be the erection, as soon as the infantry are across the gap, of the heavier bridges for their transport.

Then there is another aspect of the question. If an advance is to continue unchecked, there must be means of pushing forward engineers to deal with the succession of obstacles that are likely to be met. With the engineers possessing a rate of movement only equal to that of the rest of the force this would have to be done by leap-frogging units from the rear over those who have stopped to work. This might be a feasible proposition when the force is operating on a narrow front. A division moving along a single road would have

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four engineer units available for leapfrogging, and might reasonably count on being able to cope with the obstacles likely to be met in the course of a day's advance. But with a more extended front the engineers cannot be distributed in such depth, and leapfrogging would only be possible by mingling units from formations in rear. Such a procedure would involve complications in command, and is to be avoided if possible. A more satisfactory method would be to make the engineer units more mobile than the formations they work with. This would render it easier for them to regain their position in the advance after having been left behind to complete some task, and would facilitate their lateral movement across the front, thus compensating for the loss in depth that occurs when the frontage is wide.

For the above reasons it seems not only unnecessary but also undesirable that the method of transportation adopted by the divisional engineers should conform exactly with that used by the infantry. If the engineers are to carry out their duties and at the same time keep up with the rest of the force, their mobility must be greater than that of the latter. It appears, therefore, that engineering personnel should normally not be required to march. The mechanicalization of the engineers consequently concerns the movement of the men, as well as the technical equipment, stores, etc.

We have now to consider the choice of vehicle. The bulk of the division is still equipped with wheeled transport. Hence it is primarily dependent for movement upon roads. Work in connection with these, including bridging of course, has become in consequence the most important of the engineers' functions. Ability to move along roads at adequate speed is therefore the first essential of their transport. At the same time there are sure to be numerous occasions when the engineers have to move across country. A fast-moving cross-country vehicle such as the Dragon would give the requisite mobility, both on roads and off them. But we have ruled out the general use of specialised vehicles for the period of improvised mechanicalization, and so are limited to a decision between wheeled transport and commercial tractors, or possibly to a combination of both types. The first gives speed but not movement across country, and the second is slow. There are obvious drawbacks to the use of both types in one unit, and it will be better to adopt one or the other. The wheeled vehicle is the best for work on or near roads. The question is whether its use will prevent the engineers from preforming their cross-country duties efficiently.

The crux of the matter is the tool cart. Must this vehicle be able to move across country? The answer is in the negative if we consider a campaign in a well-developed country. There will be sufficient roads or lanes to bring the engineer vehicles as close to their work as the enemy is likely to allow. With any form of transport, movement from here would have to be on foot and the tools carried. The

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disadvantages of such a procedure are not serious. As a rule, only a proportion of the contents of the tool cart will be wanted for any one task, and it is usually possible to forsee the requirements. Moreover, the heaviest single item that might be wanted in a hurry, the exploder, weighs only twenty-seven pounds, and so is quite portable. Under such conditions, therefore, the use of a wheeled vehicle as a tool cart need not impair the efficiency of the engineers. There is no necessity to take the case of fighting in undeveloped territories, since these afford small scope for the employment of a force mechanicalized, as ours is at present, with a large proportion of wheeled vehicles. It appears, therefore, that wheeled transport will answer the purpose of the divisional engineers.

As regards size of vehicle, we have roughly a choice between light lorries (30 cwt.) and heavy ones (3 tons). The divisional train is equipped in the main with the former, but the ammunition company is likely to use the latter. We have not considered the question as to which should be employed for moving infantry personnel, but it is possible that the light lorry will be selected, since it will just carry two sections, thus ensuring an economical load without breaking up units. However, there is no reason why the whole division should be equipped with the same sized lorry. Probably both the 30 cwt. and the three-ton vehicles will be used. So far as the engineers are concerned, it is a question of which of these two will prove the more suitable.

The war strength of a section of a field company, excluding the five drivers who would be replaced by M.T. personnel, is 51 all ranks. These could be carried either in three 3-ton lorries at 20 each, or in four 30 cwt. lorries at 13 apiece. The latter method wastes none of the vehicle's carrying capacity, and allows the section to be subdivided for work into four portions, each with its own transport. The total weight of tools, technical stores and baggage which are now distributed over the tool cart, two L.G.S. waggons and a pack animal is about 28 cwt. If an additional 2-3 cwt. be allowed for boxes and fittings, and the blankets and baggage be transferred to the personnel vehicles, the whole of the section's tools and technical stores would form a very suitable load for one light lorry. This type is evidently adapted to the requirements of a field company.

Personnel and Equipment.—Having dealt with organization and transport, there remains the question of efficiency as influenced by personnel and equipment. Training is beyond the scope of this essay, and it is assumed that what is required will be forthcoming. Apart from this and the policies as regards organization and transport which we have discussed above, the output of the engineers will depend upon the suitability or otherwise of their men and plant for the work required of them.

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The new *War Establishments* (1) show an alteration since pre-war days in the distribution by trades of the rank and file in a field company. We may divide the tradesmen into three broad groups :—

(*a*) Mechanical trades, including smiths, electricians, engine drivers, fitters, plumbers, etc.

(*b*) Building trades, including bricklayers, carpenters, joiners, masons, painters and decorators.

(*c*) Miscellaneous trades, including clerks, draughtsmen, farriers, miners, saddlers, surveyors, wheelers, etc.

The proportions of these groups have been changed as follows :—

(*a*) Mechanical trades, nearly 25% of the tradesmen in 1914, have been increased to 42½%.

(*b*) Building trades, nearly 55% of the tradesmen in 1914, have been decreased to 45%.

(*c*) Miscellaneous trades, just over 20% of the tradesmen in 1914, have been decreased to 12½%.

This new distribution evidently recognises a larger proportion of "mechanical" work for the engineers than hitherto. We must see whether it will suffice under the conditions of improvised mechanicalization.

The effects of these are mainly in the direction of increased speed and at the same time greater solidarity. The tasks will remain generally as before, but we may expect :—

(*a*) Higher proportion of bridge construction and road maintenance.

(*b*) Greater use of steel, especially for bridging.

(*c*) More demolitions.

(*d*) Increased employment of motor-driven pumps, electric plants, etc.

(*e*) Less work on front line defences, but greater elaboration of rear systems.

(*f*) Fewer and smaller services in connection with water supply.

Evidently there will still be a demand for skilled labour of most, if not all, of the trades now included in a field company. Whether the existing proportions will remain correct it is difficult to say without further practical experience. The mechanical trades will be in full demand for a certainty. But so will the building trades. Carpenters are always useful; bricklayers and masons will be needed for work on culverts, concrete dugouts, etc. Miners, too, will be wanted for their own trade and usually provide the most suitable men for demolition work and quarrying. The writer is of oponion, therefore, that no further change in the proportion by trades should be made at present.

As regards tools, no revised field service manual for a field company has been issued since the war. So far as is known, companies

(1). Part XXIIIa.

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are carrying much the same war outfit, excepting, of course, bridging material, as they did in 1914. Presumably this will be modified to meet the altered distribution of tradesmen.

The question of using mechanical plant as an aid to more speedy work has been raised of late, but it is doubtful whether much could be done with it in field companies.

Mechanical plant usually requires a permanent crew, and if introduced on any considerable scale would decrease the flexibility of the units without a commensurate gain in efficiency. The field park company is provided with a mobile workshop which includes a circular saw. This should meet the normal requirements of divisional engineers. On occasions, no doubt, petrol pile-drivers and air-compressor plants would be valuable for salving and re-erecting damaged girders, for drilling existing girders, for reinforcement, etc., but they should normally be kept in rear until required, and then sent up with their own crews. Their proper place is not with divisional troops, but with army troops companies, bridging parks and the like.

Mechanicalization of the Divisional Engineers.—We will now apply the conclusions reached above to the improvised mechanicalization of the divisional engineers. The decisions arrived at may be summarized thus :—

(*a*) No change to be made in the general organization.
(*b*) Mechanicalization to be carried out with 30 cwt. lorries.
(*c*) No further change in personnel or equipment.

Taking these as the principles upon which to found the scheme, and basing our calculations upon *Provisional War Establishments* XXIII *a* (*Small War*), we arrive at the following suggestion for the first stage of the mechanicalization of the divisional engineers :

H.Q. Divisional Engineers.

H.Q. Divisional Engineers.	Motor-car.	M/c. and sidecar.	Light lorry.	Trailer.
Cmdr., Adjt. and R.S.M.	1			
2 Orderlies..		2		
Sgt. and 8 O.Rs			1	
	1	2	1	—

Field Park Company.—This unit is already mechanicalized. The only changes necessary are the replacement of the horse-drawn water cart and travelling kitchen by vehicles which can be trailed behind the lorries, and the substitution of two motorcycles with sidecars for the two riding horses.

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Field Company.

	Motor-car.	M/c. and sidecar.	Light lorry.	Trailer.
Headquarters :—				
Major, C.S.M., Trumpeter	1	—	—	—
Capt. and one O.R. ..	—	1	—	—
C.Q.M.S. and 9 O.Rs ..	—	—	1	—
Officers' Mess & 2 Batmen	—	—	1	—
Water cart	—	—	—	1
Travelling kitchen ..	—	—	—	1
Technical Stores and Baggage	—	—	1	—
	1	1	3	2
4 Sections, each.				
Subaltern and one O.R. ..	—	1	—	—
Sgt. and 12 O.Rs ..	—	—	1	—
Cpl. and 12 O.Rs ..	—	—	1	—
Cpl. and 12 O.Rs ..	—	—	1	—
Cpl. and 6 O.Rs ..	—	—	1	—
Cpl. and one O.R. ..	—	1	—	—
Tools and one O.R. ..	—	—	1	—
Technical Stores, Baggage and Cpl.	—	—	1	—
	—	2	6	—

II. THE SECOND STAGE–PARTIAL MECHANICALIZATION

PARTIAL MECHANICALIZATION AND THE ARMY.

Advance of Mechanicalization.–We have seen how in the first stage mechanicalization was largely a matter of improvisation. It is now to be carried a step further by the creation, *ab initio* if necessary, of the mechanical force most suited to our needs and resources.

The whole question of mechanicalization is still very much in the embryonic stage, and this is particularly so as regards completely mechanicalized forces. The late war furnished no instances of their employment. During subsequent peace time training there have been several exercises with temporarily formed mechanical columns, as well as a number of paper schemes involving their use. In addition, those in search of the requisite vehicle have held numerous trials and reliability tests. To a great extent the results of all these

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exercises, schemes and trials have proved inconclusive, but this is a common failing of most peace exercises. Nevertheless, though it is clear that the problem of mechanicalization bristles with difficulties, there is no evidence of a diminished belief in the potential value of a mechanical force provided this can be properly constituted and is correctly handled.

The creation of one or more of these forces as permanent parts of the army seems almost a certainty. Whether this will take place shortly or in the distant future it is impossible to say. But it would not be unreasonable to assume that, with the British expeditionary force remaining at its presemt strength of some five divisions, the equivalent of one of these at least will ultimately be transformed into a mechanical force, and provision will be made for a like treatment of a proportion of the Territorial Force in the case of a major war. We will make this assumption the starting point of our discussion of partial mechanicalization, and will now consider the effect of this upon methods of fighting.

Possibilities and Effects.—An early decision is of the utmost importance in war, and if we except the air arm, the employment of which does not come within the scope of this paper, there is no force so likely to obtain it as a fast-moving hard-striking mechanicalized one. Consequently we may expect a nation that possesses a sufficiently strong force of this nature to use it vigorously at the outset of the campaign, in the hope of dealing the enemy a paralyzing blow. To consider how opportunity for such action will arise and may be taken advantage of, we will examine various types of campaign separately :—

(*a*) *A major war against a partially mechanicalized enemy in a "European" terrain.*—The side having the initiative will probably launch its mechanicalized forces at once, supporting them by strong air fleets. They would seek to defeat or evade the hostile covering troops, and then sweep down upon the unmechanicalized bodies in rear, or they might move against some vital industrial or other centre, so as to hinder the enemy's mobilization. Where the opponents are equally matched and neither can be caught unawares, the delivery of the decisive blow at the start of the campaign may not be feasible. In such a case the mechanicalized forces may operate by bounds from objective to objective, paving the way for the culminating blow. Under these conditions the rest of the army would take over and hold ground gained by the mechanical forces so as to free these for further advances.

(*b*) *A major war against a partially mechanicalized enemy in an undeveloped country.*—We may imagine such a case as this occurring where some great Power is supporting the pretensions of a minor state against another great Power, and the fighting is taking place in the territory of the minor state. It is quite possible that the nature of

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the latter's country would be generally unsuitable for the employment of mechanicalized forces. How would the latter function in such an event? Let us consider the concrete, if imaginary, case of Russia supporting Afghanistan in a war with Great Britain. Against Afghanistan the Indian army could probably advance to Jalalabad and Kandahar. For further progress reinforcements would be needed from the United Kingdom or elsewhere. Whether or no these troops arrived before those that Russia would be despatching to her ally would have a most determining effect upon the course of the subsequent operations. Time in an instance such as this would be a very vital factor, therefore. It is conceivable that we should seek to gain it by delaying in some way the movement of the Russian troops from Europe. A feasible and effective means of doing so, given command of the Black Sea, might be by using a mechanicalized force to cut Russia's trans-Caspian route.

Thus, where the nature of a country is unfavourable to large scale mechanicalized operations, it is possible that whilst small mechanicalized columns only would be employed there, *e.g.*, in the above instance to move on Kabul from Kandahar say, the bulk of such forces could be used to influence the campaign by an independent mission.

(*c*) *A minor war against an unmechanicalized foe in a "European" terrain.*—In a war of this nature the chief share of the fighting is likely to fall to the mechanicalized forces. The chances of an early decisive success might well be most favourable. Even if they were not, the role of the unmechanicalized part of the army will be confined, in all probability, to the securing and holding of a base or jumping off ground for the mechanicalized force, and to taking over from it objectives gained.

(*d*) *A minor war against an unmechanicalized foe in an undeveloped country.*—This class of campaign has figured frequently in the past history of the British Army and may continue to do so. The final outcome of struggles of this type is seldom a matter of doubt. How to obtain a rapid decision has been the problem as a rule. A protracted struggle is undesirable, not only on account of its higher cost, but because it encourages waverers, who might otherwise not have taken part, to join in, and so widens the area affected. Mechanicalized forces will make for speedy results, provided that the nature of the territory permits their use. In countries such as Iraq it might be possible to rely upon them almost entirely, and success would be sought by a rapid dash to the objective. But in some parts of the world, notably on the north-west frontier of India and in the swamp and forest areas of the Sudan, conditions are so unsuited to mechanical movement, except along prepared tracks, that mechanicalized forces could scarcely be employed off these. Their role then would be a subsidiary one, limited mainly to the protection of the lines of communication.

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We may conclude, therefore, that, except in some small wars in very difficult territory, there will usually be no lack of opportunities for effective action by a mechanicalized force. The next question is a consideration of the tactics it is likely to adopt to take advantage of these chances. The essence of the employment of a mechanical force must be vigorous offensive action. Full use should be made of its great mobility to surprise the enemy and shatter him before he is ready to withstand the powerful onslaught. Simplicity and dash should be the keynotes of the force's tactics. There will be little time to make plans, and reconnaisance before action must necessarily be limited. But its speed and armament will enable it to take risks which a slow-moving unmechanicalized force could not afford.

Normally the mechanicalized force will operate independently of the remainder of the army. This does not imply, however, that it needs no communications. Its mobility and its power to move across country certainly allow considerable latitude in the choice of these, but it cannot do without them altogether so long as its radius of action is not unlimited. On occasions it might be possible for the personnel of the force to live on the country. One can hardly anticipate this as regards fuel and munition supply. A base of some sort is sure to be an essential, either as a place to which the mechanicalized force can return to refit or to replenish its resources, or from which its trains may be sent up to it. Communication with this base must be assured, and so must be the safety of any trains despatched thence. So long as rivers, woods, mountainous areas, marshes and the like remain impassable to mechanical vehicles,—and as yet we cannot visualize any single conveyance capable of negotiating all these obstacles—there will be opportunities for severing the communications of the mechanicalized force. The latter's position, if it cannot regain them before its fuel supplies are exhausted, is likely to become precarious.

In attacking unmechanicalized formations the mechanicalized force will find its most favourable opportunity when its opponents can be caught on the move. If the latter are unassisted by armoured vehicles there will be every chance of overrunning them before their artillery can intervene effectively. So great, in fact, is this danger to which unmechanicalized formations are now exposed that they may be expected to move by bounds from one prepared position to another, quitting each only as they are assured that the route to the next is clear.

The dominating role in the fighting of this period then is likely to be played by the mechanicalized force. Acting as the spear head of the army, it will conduct a vigorous offensive well in advance of the unmechanicalized troops. If it cannot destroy the opposing mechanicalized columns, it may seek to evade them, and by rapid movement surprise and crush the forces in rear. The unmechanical-

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ized portion of the army will further the other's operations by taking over ground captured, by holding vital defiles, bridgeheads, etc., so as to ensure its safe communications, and by occupying positions difficult of attack, and behind which the mechanicalized force can withdraw to refit.

The mechanicalized force.—We will turn now to the organization of the mechanicalized force. The starting assumption for our discussion of this period has been the mechanicalization of a force equivalent to a division. This force must be prepared, as our examination of the probable nature of the fighting has shown, to operate to a great extent independently of the rest of the army. Obviously, therefore, its organization must be a self-contained one. That is to say, it should include a proportion of fast-moving vehicles for reconnaissance, a main body of adequate striking power and sufficient speed, enough supplies and munitions to give the force the necessary radius of action, and such facilities for crossing gaps as will ensure its freedom of movement. The non-fighting vehicles must be kept to a mimimum of course, or the offensive power of the force will be reduced.

The next desideratum is that the organization should be a permanent one, as opposed to a temporary grouping of units when the need arrives. The speed at which the mechanicalized force has to move and fight is so great that its successful employment calls for an extremely high degree of tactical efficiency and, consequently, for much training in co-operation between its components. Therefore the force must be trained as a whole in peace, or it will fail to function efficiently in war.

Is the equivalent of a division to be taken as the permanent organization, or would a smaller force, say one corresponding to a brigade group, prove more suitable ? In the writer's opiniom the latter is the one to choose. Though the role of the British Army is a varied one, the smaller force is, perhaps, more likely to be in demand than the larger one. Moreover the training of the brigade group column would be easier than that of the divisional formation, and in consequence, it would be possible to reach a higher standard of efficiency. Whichever force be adopted as the permanent one, it should, for the best results, be concentrated in one training area. There would be greater opportunities for a knowledge of the capabilities and methods of mechanicalized forces permeating the rest of the army, to the mutual advantage of all, if three mechanicalized brigade groups were stationed one each in, say, the Aldershot, Salisbury Plain and Catterick areas, than there would be if a mechanicalized division were located at one of these centres. For these reasons, therefore, the brigade group force will be adopted, and we will assume its organization to be as follows :—

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Mechanicalized Brigade.

Brigade Headquarters.
Regt. Armoured Cars (3 coys. each of 16 armoured cars, semi-track).
Tankette Bde. (4 Bns. each of 48 two-men tankettes).
Tank Bn. (3 Coys, each of 48 Vickers tanks).
Field Bde. R.A. (mechanicalized, Dragons).
Field Coy. R.E. (mechanicalized).

The main characteristic of this force would be that every unit and every vehicle would move ready for instant action. The speed of the armoured cars would be 30 miles per hour along roads and 15 miles per hour across country, that of the rest of the force 20 miles per hour on roads and 10 miles per hour off them. The whole force would have a 300-mile radius of action and every unit would, for this distance, be self-contained as regards fuel, munitions, supplies and spares.

As regards ability to move across country, it may be taken that ordinary hedges, banks and ditches would present no difficulty to the force. The track vehicles could negotiate ditches up to 6 feet wide and banks up to 4 feet high with a slope of 1 in 2. The armoured cars with their greater speed would be able to make a detour round obstacles they could not cross. In addition, it is assumed that the tank battalion will include a number of bridge-laying tanks, say two per company, which can bridge gaps up to 15 feet without exposing their crews. These bridges could be used by all units of the force.

The capabilities of the field company with the mechanicalized brigade will be dealt with in the next section.

Partial Mechanicalization and the Engineers.

What is required of the Engineers.—Having discussed the effects of partial mechanicalization upon warfare, and evolved a possible composition for the mechanicalized force which is to be the feature of this stage, we are now in a position to examine the engineering needs of the army, and to see how they are to be met.

Mechanicalization being a process of evolution we may expect armies in this period to include formations in all degrees of formation. It is intended for the sake of clearness, however, to deal with them in only two categories :—(*a*) completely mechanicalized forces ; (*b*) other forces. Engineers will be required with both and, though the principles of their employment will be the same in each case, their methods of performing their duries may differ considerably, just as the work of a field squadron varies from that of a field company. So we will take the two separately.

Let us begin with our permanent mechanicalized formation, the mechanicalized brigade. The fundamental principle governing the employment of this force is mobility. Freedom of movement will be the keynote of its success. This clearly indicates the primary

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function of its engineers. They will have to assist the force to retain its mobility. In other words, their most important duty will be bridging. They must be able to get the mechanicalized force over any obstacles it may meet and which it cannot cross unaided.

The tactics of the mechanicalized force are essentially offensive. Its aims will be to deal the enemy a paralyzing blow, and to do this it may strike directly at the hostile forces or at some vital point in rear. In the former event it may be desired to cut the enemy's line of retreat and so prevent his escaping the blow, whilst in the latter the objective may well be the destruction either of some industrial plant or of an important bridge or railway crossing. Operations of this nature will demand an extensive use of what may be termed offensive demolitions. The latter may be wanted for purposes of defence as well. Should an attacking force wish to prevent the intervention of a hostile contingent before it had gained its objective, the destruction of crossings which the enemy had to use and the laying of minefields in areas he must pass, might delay the latter sufficiently, whilst avoiding the necessity of making a large and, perhaps, ill-spared detachment for the purpose. In the case of a withdrawal, obstacles of all forms, demolitions, mines, barricades, etc., will be needed to force the enemy off the roads and across country, thus slowing up the pace of the pursuit. On these occasions time will be of the utmost value, and it will rarely be possible to erect elaborate road blocks or barricades. The demolition of some crossing is usually the most rapid, and at the same time most effective, method of checking the enemy advance. Caution may be imposed on the pursuer, too, by the judicious laying of mines, and where it is possible to explode one under an armoured vehicle in a narrow defile, a serious block may be caused.

Not much is likely to be required in the way of field fortifications. The mechanicalized force's best defence is its mobility. It is unsuited to the occupation of positions and passive defence. As a rule it will only have to hold a locality until it can be relieved by the other forces in rear, and it will probably rely on rapid counter-attack as its most potent means of defence.

To sum up: bridging, demolitions, mines and obstacles will form the most important of the duties of engineers with the mechanicalized force. In the execution of these tasks the dominating factor, consistent with adequacy, will be speed.

What about the engineers with the rest of the army? The latter's role and consequent requirements will depend mainly upon the operations of the mechanicalized force. If these have been successful, and the rest of the army has merely to take over the ground gained, its chief need will be mobility, so that there may be no delay in freeing the mechanicalized force for a further advance. So far as the

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engineers are concerned, this implies bridging and road communications generally.

There is always the possibility that the hostile mechanicalized forces may evade those of the attacker and strike at the other forces in rear. Consequently these must be prepared to resist a sudden mechanical attack. There will seldom be time for elaborate field works. As a rule the most that can be done will be to narrow down the possible avenues of approach so as to give the defending artillery more chance of coping with the attack. Demolitions, mines and obstacles are the best means of thus restricting movement.

Where an army is inferior as regards mechanicalized forces, its chief engineering need will be protection against mechanical attack. Though there can be no question of providing defences along an extended front, a great deal will be possible in the way of improving and strengthening natural obstacles.

Generally speaking, therefore, the engineering tasks will be much as they were for the mechanicalized forces. But there should be more time for their execution, and in consequence the work will be more elaborate and more extensive. Bridges will have to take heavier traffic and will be used more ; minefields will be wider, and obstacles will be more numerous and stronger.

Changes to meet the New Conditions.—We must now consider the organization of the engineers for these tasks. In the period of improvised mechanicalization the divisional and corps engineers were equipped with wheeled mechanical transport. No cross-country vehicles were provided for them, and their tools and organization remained essentially as they were at the close of the Great War. The mechanicalization of the engineers has now to be continued a step further.

We will take first the engineers with the mechanicalized brigade. This force, as we have seen, is to have a permanent organization. It will operate to a large extent apart from the remainder of the army and its tactics will to some extent be peculiar to it. If the engineers are to co-operate efficiently with the force, they must live with it and be trained with it. They must form a part of it in peace as well as in war. Temporary attachment would not meet the case. Hence the first essential of the new engineer organization is that it should be a permanent part of the mechanicalized brigade.

The next point is the strength and equipment of this engineer unit. It will be governed by the nature and extent of the tasks required from the unit by the mechanicalized brigade. The most important of these, as we have seen, are bridging, demolitions, mines and obstacles. There are many others, but these four may be looked upon as the chief tactical functions of the engineers, and their organization must be based upon them. We will deal with the four *seriatim* :—

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(*a*) *Bridging.*—We have assumed that the mechanicalized brigade can negotiate gaps up to 15 feet unaided. For wider spans engineer assistance will be needed. To what extent should bridging material be provided ?

The mechanical brigade must effect its passage over obstacles by surprise. The crossing of any considerable gap with a determined enemy in occupation of the far bank would not be a feasible operation. It is essential that the bridge be launched where the enemy is not ready to resist it, or where he can only oppose it with machine gun and rifle fire. Surprise is obviously necessary, therefore. It can be achieved by speed, that is to say, by reaching the obstacle so far in advance of the enemy that there is time for the bridge to be launched and for sufficient of the force to have crossed over before the opposition is in strength. Air reconnaissance and wireless telegraphy have increased the rate at which information of such an attempt may reach the enemy, whilst mechanicalization has given him the means of rapid movement to forestall it. Under the most favourable circumstances it is doubtful if the bridging party could count on more than six hours in which to complete their task, and it will often be less.

If surprise cannot be obtained by speed, it may be gained by dispersion ; by attempting the crossing at more than one spot in the hope that the enemy will either have so distributed his forces as to leave them too weak everywhere or, that he will have concentrated at some spots and left others unguarded. Time will again be the deciding factor, and we cannot rely on a more generous allowance than we have made for the single crossing. Moreover, an attempt at several places simultaneously demands a corresponding number of bridges. For our mechanicalized brigade four bridges, at least, would have to be carried.

Finally, there is the chance of securing surprise by concealment. The crossing might be made under cover of darkness, fog, in a storm, or by moving to the site concealed by woods, buildings, etc. It is unlikely that there will be any increase in the time available, and the successful employment of this method requires a standardised equipment and a highly-trained bridging personnel.

The *desiderata* of the bridging equipment may, therefore, be summed up as follows :—

(*a*) Maximum span to be such that it can be erected and launched within six hours.

(*b*) Provision to be made for four separate bridges.

(*c*) Type to be simple, and suitable for erection in the dark.

(*d*) Equipment to be standardised, and to form a permanent part of the engineer unit, so that the requisite training of the personnel may be ensured.

(*e*) It must be possible to assemble the bridge under cover, and then to launch it in face of machine gun and rifle fire.

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(*f*) The transport required must not be such as will render the mechanicalized brigade unwieldy or impair its fighting efficiency by necessitating strong detachments as a guard.

The longest single span erected during the Allies' advance in the autumn of 1918 was 180 feet. There would be no great technical difficulty in designing a bridge of this span capable of taking the loads with the mechanicalized brigade. But such a bridge would not satisfy the conditions above. It could not be launched in anything approaching six hours, nor is it adapted to erection under cover and launching by pushing out, so that it could not be thrown across in face of hostile machine gun and rifle fire. Further, the provision of four such bridges would entail a far too lengthy column of vehicles. We must rule out bridges of this length. The need for them will usually be foreseen and special provision made. Something smaller is required for the normal purposes of the mechanicalized brigade.

The Inglis bridge, rectangular type, Mark II, with 15-foot bays, will carry 35-ton tanks over 105 feet. It has been designed so that it can be made up complete under cover, and then pushed across country by a tank and over the gap without the use of special platforms or runways. It can be launched in this manner over a 70-foot gap or, in very good conditions of ground, over a 100-foot gap. With trained personnel the erection and launching of the steelwork can be done in 2½ hours. All the launching operations can be controlled from within the tank, and can, therefore, be done in face of machine gun and rifle fire. A party of some 50 sappers is suitable for the construction of the bridge. Its weight is 6 tons per 15-foot bay, and it can be carried in 28 three-ton lorries or an equivalent number of tracked vehicles.

This bridge satisfies the conditions we have laid down. It will not, however, be feasible to include four 105-foot spans with the mechanicalized brigade. If the bridging train is not to be unduly long a total length of 120 feet is about the maximum that can be taken. By providing 4 sets of launching frames, it would be possible to erect four 30-foot span bridges, or two 60-foot ones simultaneously. And a single bridge of 105 feet could be built if necessary.

The Inglis rectangular bridge, Mark II, will be adopted, therefore, as the standard type, and the engineer organization must be arranged for its erection, either in several small parts or as one 105-foot bridge.

(*b*) *Demolitions* :–These are primarily the task of small detachments of which several may be required at the same time. Work of this nature will not vary greatly from that for which the divisional engineers are trained at the present day. With the existing field company organization, however, there is no special demolition detachment. There are several reasons why provision should be made for this in the engineer unit of the mechanicalized brigade. In the first place, the bridging work is of such importance, and demands

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for its efficient and rapid execution such a highly-trained personnel, that it is undesirable that duties other than bridging should be included in the latter's normal role. To do so would not only prevent their acquiring as high a standard in the work of bridge erection as they would be likely to do if that formed their sole duty, but it might lead to a weakening of the strengths of the bridging parties below the level at which they could function efficiently. Demolitions frequently involve dispersion of the parties engaged in the work over considerable areas. Apart altogether from the casualties likely to be incurred at the work, the question of concentrating these parties afterwards for a bridging operation would be a difficult and often an impossible task, in view of the speed at which the mechanicalized force moves. We may conclude, therefore, that demolition work should not normally be done by the bridging detachments. It must, then, either be the function of a separate unit or of a special detachment in the company that finds the bridging sections. The former method appears unnecessarily extravagant of engineer troops. It is likely, too, to introduce difficulties as regards command. If there are more than one engineer unit with the force there must be an officer superior to both commanders to co-ordinate their work. By including the demolition detachment under the same command as the bridging work the force commander will have only one engineer officer to deal with. Moreover, it will be quite feasible to give the demolition personnel sufficient training in bridging duties to enable them to replace casualties in the bridging sections. For these reasons the demolition detachment should form part of the same engineer unit as the bridging sections, though its personnel would normally move and work separately from the latter.

(*c*) *Mining*—As we have previously stated, the extent to which mines can be used will depend primarily upon the transport available to carry them. Suitably placed minefields impose caution upon the pursuit, and so delay the pursuer. In certain cases they may form a very efficient obstacle, as, if laid in a defile or on a causeway and exploded beneath an armoured vehicle, the route may be very effectively blocked. Only a small charge of high explosive is required to break the tracks of an armoured vehicle and so bring it to a halt. A mine weighing not much more than 10 lbs. should be all that is necessary. With these small mines a minefield could be laid very quickly, and would not be easily detected by an advancing enemy. Their real disadvantage lies in the question of supply, for a considerable number will always be necessary to ensure adequate results from their employment. A mechanicalized brigade group cannot carry a very great quantity, so their use is likely to be limited to situations of urgency (*e.g.* retreat), and to positions such as defiles, roads, etc., which it is reasonably probable the enemy will use, or which it is important he should not be allowed to cross unmolested. Mines,

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therefore, will be primarily used as a means of defence, and hence, probably in conjunction with defensive demolitions. Their transport and laying will best be provided for by the demolition detachment.

(*d*) *Obstacles.*—These, like mines, are measures of defence. The two, in fact, really belong to the same category, mines being merely a special type of obstacle. Mines will usually form the quickest means of creating an obstacle, but their limited quantity may necessitate the employment of other methods to supplement them. These will take the form of blocks designed to make the enemy leave the roads and move across country. They will be of little value in open country, where a short detour will avoid them. But in wooded country, mountainous or marshy areas, and in large towns, their value may be considerable. Wooded country lends itself to the construction of barricades across roads by felled trees. In mountainous districts, demolitions at narrow and difficult places in the roads are probably most effective. Roads or tracks across marshes can only be blocked by the creation of gaps in them. As a rule, it will not usually be feasible to create gaps so large that they cannot be easily bridged. Mines are probably more efficient generally in such cases. Movement through town areas can be checked and delayed by barricades, the material for which will be obtained most quickly by demolishing buildings with explosives, and by placing vehicles which have been rendered immobile across the roads. Work of this nature can all be carried out by the demolition detachment. A liberal supply if explosives is essential, and vehicles capable of dragging heavy weights would be useful.

To sum up the requirements of the mechanicalized brigade group as regards its engineers :—There should be one unit capable of finding 4 bridging detachments, each of which will be able to erect a 30-foot bridge, and is self-contained as regards the material, transport and personnel required for this, and, in addition, a demolition detachment provided with personnel, explosives, tools, and transport for the demolition of at least 6 bridges simultaneously, for crater work in roadways, for the demolition of banks, cuttings, causeways, the destruction of buildings, the erection of road barricades, felling of trees and the laying of minefields.

We must now turn to the engineers employed with the rest of the force. It is not proposed to deal with these at great length. Their role will not be altered essentially from what it was in the first stage of mechanicalization. To a certain extent, however, it will be rendered more difficult, since the forces they are working with will be more liable to sudden attack from the enemy's mechanicalized forces. Apart from bridging, the importance of which remains unchanged, the provision of anti-tank obstacles will, therefore, become more urgent. The methods employed for these will be similar to those described for the engineers of the mechanicalized force. The

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need for more elaborate and extensive work is evident, however, since the unmechanicalized force is not adapted to resist the mechanicalized one without suitable obstacles, natural or otherwise, and failing such, has not the same power of movement by which to avoid the encounter. Whilst, therefore, we may accept the organization adopted for the stage of improvised mechanicalization as being still generally applicable, provision will have to be made for a more extensive use of mines and obstacles. This implies movement across country, because in this case the mines and obstacles are wanted, not only on roads, but at weak or exposed points along the whole front. To fulfil their roles at adequate speed the engineers must consequently be provided with cross-country vehicles.

The further Mechanicalization of the Engineers.—It now remains to detail the organization of the engineers in accordance with the conclusions arrived at above. The following are the writer's proposals :—

(*a*) Engineers with the Mechanicalized Brigade—

1 FIELD COMPANY R.E. (Mechanicalized).

Composition—Coy. H.Q.. . . . . Major, Capt., C.S.M., C.Q.M.S., Clerk.

Headquarter Wing :—Wing H.Q., Capt., Clerk, Orderly.

No. 1 Group. (demolition section) 2 Subalterns and 54 O.Rs.
No. 2 Group. (administrative details, orderlies, etc.)
No. 3 Group. (technical stores and tools). (4).
No. 4 Group. (reserve bridging section). (5).

4 sections :— each 2 Subalterns and 54 O.Rs.

Transport— Coy. H.Q. . . . . 2 light track vehicles.

Headquarter Wing :—Wing H.Q. 1 do do vehicle.
No. 1 Group. 2 do do vehicles and 4 dragons. (1).
No. 2 Group. 1 dragon (2).
No. 3 Group. 2 dragons (3).
No. 4 Group. 4 do (3).

4 sections :— each 2 light track vehicles 4 dragons (3).

(1) Each 2 N.C.O.'s, 12 O.R.s, explosives and tools.
(2) Cooker trailed.
(3) Each dragon with a trailer.
(4) Reserves for No. 1 Group and the 4 sections; includes mines.
(5) Material only for one 30-foot bridge.

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(*b*) Engineers with the rest of the army.

Per division. .. . . . .H.Q. DIVISIONAL ENGINEERS.
FIELD PARK COMPANY.
3 FIELD COMPANIES.

No change has been made in the organization of the divisional engineers. Their transport, however, is now all track, and additional vehicles have been added to carry mines, the supply of which is replenished from the ammunition company, R.A.S.C.

Per Corps. . . . .Army Troops Companies, Bridging Parks and Pontoon Trains allotted as required. All equipped with wheeled mechanical transport.

III. THE THIRD STAGE—FULL MECHANICALIZATION.

Mechanicalization as it is likely to concern the present generation is comprised within our two first stages. But there is small chance that the transformation will stop there. So far as can be foreseen, the replacement of man-power by machine-power will continue much further. It may even reach the ideal army consisting of one man who, by pressing a button, puts into operation war machines evolved by the best brains of the nation during peace time (1). However, such a distant view hardly comes within the scope of this article, and the writer does not propose more than a glimpse into the immediate future.

The facts that formed the foundations for our conclusions concerning the first and second stages of mechanicalization are no longer available. We shall have to quit the sure paths of knowledge and attempt the quicksands of conjecture. Yet it may be that there will be some gain from this, nevertheless. Dreams of the future ought not to be allowed to obscure the actualities of the present. But this does not imply that advanced thought should be ignored. Far from it. Those who keep in close touch with scientific progress will be able to take prompt advantage of what science offers. They will have the opportunity of adapting a new discovery, or process, to the military needs of their country and in advance of her rivals. By such means surprise in material, one of the most potent and lasting forms which this most powerful of weapons may take, can be achieved. This is ample reason for looking ahead, and it applies to the science of mechanicalization as to others.

What, then, can we see of the war of the future? Every indication points to the eventual disappearance of man as a self-propelled agent of war. Whole armies will be carried to the battlefield and through the fight. Full mechanicalization will provide the soldier with the means of movement, equip him with the powers of destruction, and armour him against the enemy's weapons. Man's functions will be to guide and control the machine.

(1). "Tanks in the Great War" (Fuller), p. 310.

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Battles may well assume some of the aspects of a naval action. As the evolution of the mechanical vehicle progresses so will its ability to traverse all natures of surface improve, until difficult country offers no greater obstacle to its advance than a rough sea does to the manœuvres of a man of war.

Consequently, trenches as we now know them, and all the ordinary types of obstacle, will become useless. In fact, field defences of all sorts will be obsolete. Nothing but permanent works on a scale far greater than anything now contemplated will afford protection from the mechanical attacks of the future. We may picture the defences of this era as consisting of enormous moats and vast minefields. Their construction in time of war would be impossible. Fortification therefore, will be done in peace time. It will be necessary, in order to secure our great strategic and industrial centres, our land and air ports, power stations, fuel depots and the like. The development of the air arm, a phase of mechanicalization, but one which has not been dealt with in this paper, will probably by this time have driven all important centres, depots and quarters underground, whilst progress in chemical warfare will have rendered futile any defences which are not gastight and supplied with " tinned " air.

Truly the future of warfare provides ample food for speculation. But sufficient rein has been given to the imagination. There will be little benefit in proceeding further. We will content ourselves with noting that, no matter how far ahead we look, and no matter what changes in war and its conduct take place, the need for the engineer remains. The effect of mechanicalization in no way tends to diminish his value as an auxiliary to the fighting arms, whether the latter be represented by men or by machines. It will, however, make the execution of his task more difficult unless mechanicalization be called in to aid him. The tank is the answer to the tank. In the same way " mechanical " engineering must be used to counter the effect of mechanical warfare.

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THE INFLUENCE OF INTELLIGENCE UPON THE TANNENBERG CAMPAIGN.

By BREV.-MAJOR B. C. DENING, M.C., *p.s.c.*, R.E.

FOR reasons which at first sight are not very apparent, the influence of Intelligence upon the conduct of war has not that prominence in the writings and teachings of the leaders of modern military thought that might be expected in view of theimportant part Intelligence has played in the wars of the past. Any soldier to-day, if asked, did he consider Intelligence a matter of paramount importance in war, would unhesitatingly reply in the affirmative. Yet rarely in the many studies which have been made of the events of the late war is full credit given to the effect Intelligence has had upon Operations. Possibly this is due to the fact that few of the military battles of the last war were in themselves decisive, and in consequence the direct connection between good information obtained and results achieved is not easy to trace. Whatever the cause, unless the value of Intelligence in any form of war, past or future, is ever before us, its study in peace is likely to be neglected, and its absence in war is certain to be accompanied by the failure of operations.

Of all the battles of the last war, the most spectacular, if not the most far-reaching in effect, was that in which the Germans obtained a decisive victory over the Russians in East Prussia, in the vicinity of the village of Tannenberg. For many reasons the Tannenberg campaign is worthy of study. The conditions of the campaign were those of the type of warfare known to-day as open warfare, *i.e.*, those which all soldiers hope are likely to prevail in future. The opponents, upon paper at least, were evenly matched, the superior numbers of the Russians being balanced by the greater mobility, the better equipment and higher staff work of the Germans. Finally, the results of the main battle, where the completion of the manœuvre of double envelopment ended in the encirclement and destruction of the greater portion of the Russian Second Army, were not equalled in any other of the successful battles of the war, and resembled more the era of Sedan than that of the Somme and Verdun. This battle is a suitable one for the investigation of the influence of Intelligence upon Operations.

The Battle of Tannenberg is fully described in General Sir Edmund Ironside's book, "Tannenberg," which itself is based upon three English, seventeen German, and six Russian books of reference. It is not proposed to touch in detail upon the various actions which led up to, and followed the disaster of Tannenberg, but merely to point out the stages at which the possession or the lack of information had a vital effect upon events.

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To begin with, the equipment of the two sides for obtaining Intelligence is interesting. The Germans used a certain number of reconnaisance aircraft, the Russians did not. Both armies possessed wireless, but, whereas the Germans realized the danger of indiscriminately using this method of communication, the Russians failed to do so, and either broadcasted their orders in clear, or used such simple cypher, that the enemy successfully intercepted the messages sent. The Russians possessed a considerable superiority in cavalry, but had no conception of the use of the mounted arm for the purpose of obtaining information, whereas the Germans were well served with reports by advanced detachments. The Russian signal communications were so deficient that the superior Commanders had sometimes little knowledge of the whereabouts even of their own troops. The German communications were excellent. Such were the conditions under which the fighting started.

The campaign of Tannenberg may be briefly summarised under the headings of :—

The Battle of Gumbinnen (Aug. 20th, 1914).

The Battle of Tannenberg (Aug. 26th to Aug. 30th, 1914).

The Battle of the Masurian Lakes (Sept. 9th to Sept. 14th, 1914).

The Russians advanced with their First and Second Armies (see Sketch "A" attached), the former of approximately three Corps and five Cavalry Divisions, the latter of about six Corps and three Cavalry Divisions. The Germans had in East Prussia to oppose them, the Eighth German Army the equivalent of five-and-a-half Corps and one Cavalry Division, though one additional division arrived from Germany for the Battle of Tannenberg and two corps from France for the Battle of the Masurian Lakes. The essence of the Russian plan was to unite their two armies on the battlefield in East Prussia, where they would be in a superiority of nearly two to one.

The German plan was based upon their ability to meet the Russian armies singly, and to defeat them in turn. The dependence of both plans upon good information, both with reference to enemy movements and the progress of the troops of their own side, is too obvious to require further emphasis.

THE BATTLE OF GUMBINNEN.

By 14th August, Eighth German Army Headquarters in East Prussia had information, from sources not stated, of the approach of the Russian First Army in the North, but none of the advance of the Russian Second Army from the R. Narew, as the following extracts from a German Army Order (1) show :—

> "It appears not unlikely that the enemy may advance South of the Forest of R. . . . . His advanced troops—Infantry and Artillery—are advancing from the line Gr. C.—M." (both on the frontier, about 35 miles South of Gumbinnen).

(1) General Ironside's "Tannenberg."

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"The army will concentrate on its left flank to take the offensive against the enemy's advance, etc., etc. The covering of the right flank of the Army against the, in any case, *very unlikely event of a Russian advance from the Narew*, (2) is placed in the hands, etc., etc."

The German information was as accurate as could be expected. The First Russian Army extended in fact further north than reported, while the Second Russian Army did not commence to arrive at the frontier until 20th and 21st August.

On the Russian side, early in August, raids to a considerable depth by cavalry of the First Army identified the 1st German Corps and 1st Cav. Div. Continuous touch was not maintained, however, nor was the German protective screen penetrated, as it might have been with the superiority in cavalry possessed by the Russians. The Russians had thus no news of the concentration of the Eighth German Army, which took place between 15th and 20th August, for the fight at Gumbinnen.

On the 19th August, at a most critical point, the Russian Order giving the dispositions and plans of the First Army for 19th and 20th August were issued by wireless. These were picked up *in toto* by the Germans. Rarely in the history of war can a commander have received such intelligence as fell to the German leader of the Eighth Army on that day. He was made aware of the plan of the First Army to halt on 20th August. The Germans did not, or were not, able to make full use of the information they possessed at Gumbinnen. It is true that they attacked the Russian Army, but with only a limited measure of success, the attack being too hurriedly mounted and being delivered piecemeal. Had they been able to wait one day longer, and had the German corps attacked on the 21st in line, the story of Gumbinnen would have been a very different one. As it was, Intelligence was again affecting the operations, this time adversely. The information which reached the German Army Commander by 20th August is well summarised in a telephone conversation between him and a Corps Commander :—(3)

"The situation has completely altered. New forces have appeared in the North. . . . . Fresh forces of about an Army Corps have appeared about Lyck. The Narew Army is advancing in strength. . . The Eighth Army is, therefore, going behind the Vistula."

The effect of this intelligence, particularly that relating to the Russian Second Army moving from the Narew, was to take the whole sting out of the German offensive. The Russian First Army, quite by accident, for it had no information and had halted on 20th August, had almost succeeded in retaining the greater portion of the German forces opposite it until it was too late for them to move back to meet the new danger in the South.

(2) Writer's italics.
(3) General Ironside's "Tannenberg," p.101-102.

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THE BATTLE OF TANNENBERG.

After the fight at Gumbinnen, the Germans did not, in actual fact, " go behind the Vistula," but left one Cavalry Division in observation along the whole front of the Russian First Army, and moved three-and-a-half Corps, two by road and the remainder by rail, to the Tannenberg area. Thus a few German Cavalry fixed the Russian First Army, while the Russians had little conception of the location of the German forces. The German Eighth Army, placed at this point under Hindenburg and Ludendorff, gambled on the slowness of the advance of the Russian First Army to give them time to meet the Second Army. Had the Russians but known, the First Army had only to move forward to render the position of the Germans in East Prussia quite untenable. Ludendorff, referring to the First Army Commander, says :—(4) " He need only have closed with us and we should have been beaten." To lack of Intelligence as to the true state of affairs, even allowing for all other reasons, must be attributed this criminal inactivity on the part of the Russians in the North.

As regards the information possessed by the Second Russian Army prior to Tannenberg, General Ironside shows this to have been scant. The Army Commander reported on 20th August to higher authority :— (5)

> " The frontier roads are very heavy. Reconnaisances, therefore, were only short. *Enemy aeroplanes followed the movements of the Army all the time.*" (Writer's italics).

The Second Russian Army blundered on, only vaguely aware of the presence of some enemy in front of them.

As regards the information which the Germans obtained, in addition to their air reports, General Ironside tells us :— (6)

> " The order giving the dispositions of the Second Army for the 24th was sent (by wireless) ***in clear***!"

It is hardly to be wondered at, therefore, that between the 26th and 30th August a practically blindfolded Russian Army was surrounded and cut up by a German Army roughly equal in numbers, but possessed of knowledge which made the situation to them as clear as day. There can be little excuse for the Russians, who might have neutralised the fatal use of wireless by the active employment of their 50 squadrons of Cavalry available here against some 9 German Squadrons.

Even during the battle the Germans received valuable Intelligence. Towards the end of the battle (7), the Russians collected the equivalent of a fresh division and launched an attack intended to break the southern enveloping wing of the Germans. Ludendorff says :—

(4) " My War Memories, 1914-1918," by General Ludendorff, p.49.
(5) General Ironside's " Tannenberg," p. 127.
(6) General Ironside's " Tannenberg," p.146.
(7) General Ironside says on 30th (p. 190); Ludendorff says on 29th. ("My War Memories," p. 56).

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"Early on 29th we received a message by aeroplane that a hostile Army Corps was marching on Neidenberg from the south. . . . . It was, therefore, threatening the rear of the 1st Army Corps, which, with its front facing north, was engaging Russian troops in retreat."

The aeroplane in question warned both the 1st Army Corps and Ludendorff. General Ironside states that five divisions were diverted to meet the new danger.

As a result of this battle five Corps of the Second Russian Army were annihilated.

The Battle of the Masurian Lakes.

Immediately after the battle of Tannenberg, the German forces, reinforced by two Corps from France, were turned again against the Russian First Army which had slowly advanced. This advance ceased as the news of the disaster in the south became known, and the Russians withdrew somewhat and took up a defensive position. Again the Germans had complete knowledge of the Russian dispositions, owing to the irresponsible use of wireless by the latter. This time, however, the tactical situation did not permit of the complete envelopment. Though the German right flank fought several successful actions east of the Masurian Lakes, and effected a wide turning movement, it was not able to cut off the retreat of the Russian Army. An opportune counter-attack by the Russian centre gained valuable time, and the German victory became indecisive. The Russian Corps were extricated without disintegration, and retired once more over the frontier.

Conclusions.

It were unwise not to take into account various other factors in assessing the influence of Intelligence upon the campaign of Tannenberg. General Knox has given an excellent picture of certain of the scenes behind the Russian lines, notably in the Second Army area:—(8). It is clear that the Russians suffered from lack of commanders of any ability, and lack of good staff work. They were hurried forward so fast that supplies ran short almost at once, and so that by the end of the Battle of Tannenberg men and horses were literally starving. The armies were so ill deployed that Corps were not within supporting distance of one another, and were defeated in detail. On the German side, Ludendorff claims that :— (9)

"To the training of our army in peace time, alone did we owe this feat."

Certainly the Germans had roads, railways, motor transport, signals, everything that the Russians lacked. Yet is it too much to maintain that, in spite of all these contributing factors, no decisive battle would have been won had Intelligence reached both sides in equal quantities ?

(8) "With the Russian Army, 1914-1917," by Maj.-Gen. Sir A. Knox, K.C.B., C.M.G.
(9) "My War Memories," p. 57.

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Let us suppose that Russia throughout had used her cavalry in a reasonable manner. Must they not, before each of the battles, have gained some knowledge of the extent of the German forces and given the Russian leaders something upon which to base their attacks and their assumptions? Had the Russian cavalry followed up the German retreat after Gumbinnen, surely no Battle of Tannenberg could ever have developed as it did, whatever the chaotic condition behind the Second Russian Army. And had the latter army used its cavalry in the most elementary manner could it possibly have fallen into the trap prepared for it?

And, conversely, though the reports from the air were invaluable, could the German plans at all three of the main battles have matured so quickly had the wireless not located every hostile formation on the front. And without the speed in them, the Germans plans could not have brought decisive results.

The writer is of the opinion that had Intelligence on both sides been obtained as it should have been, in spite of all their other disabilities, *the Russians* would have won the campaign of Tannenberg, by forcing, if only gradually, the retreat of the German Army by the converging pressure from north and south.

THE LESSONS FOR THE FUTURE.

The lessons for the future are clear. No military power must ever again allow Intelligence work, both preventive and productive, to be so neglected as to bring troops to such a pass as that of the unfortunate Russians at Tannenberg.

It is pretty generally realised to-day how carefully the use of the wireless in the field must be handled if vital information is not to be divulged. It is doubtful whether other means of preventing information reaching the enemy are as well appreciated. We should press on with the study of this side of the question, in order to force our enemies to fight in darkness as the Russians did in the campaign just discussed.

Conversely, we must in peace think out and organise all possible means of obtaining Intelligence. The German handling of their cavalry and advanced detachments before and after Gumbinnen show well what can be done by trained troops. It requires to become second nature to our forces, whenever contact has been obtained with an enemy, never to lose that contact, to find out every possible thing about that enemy, and to transmit the knowledge gained to higher authority.

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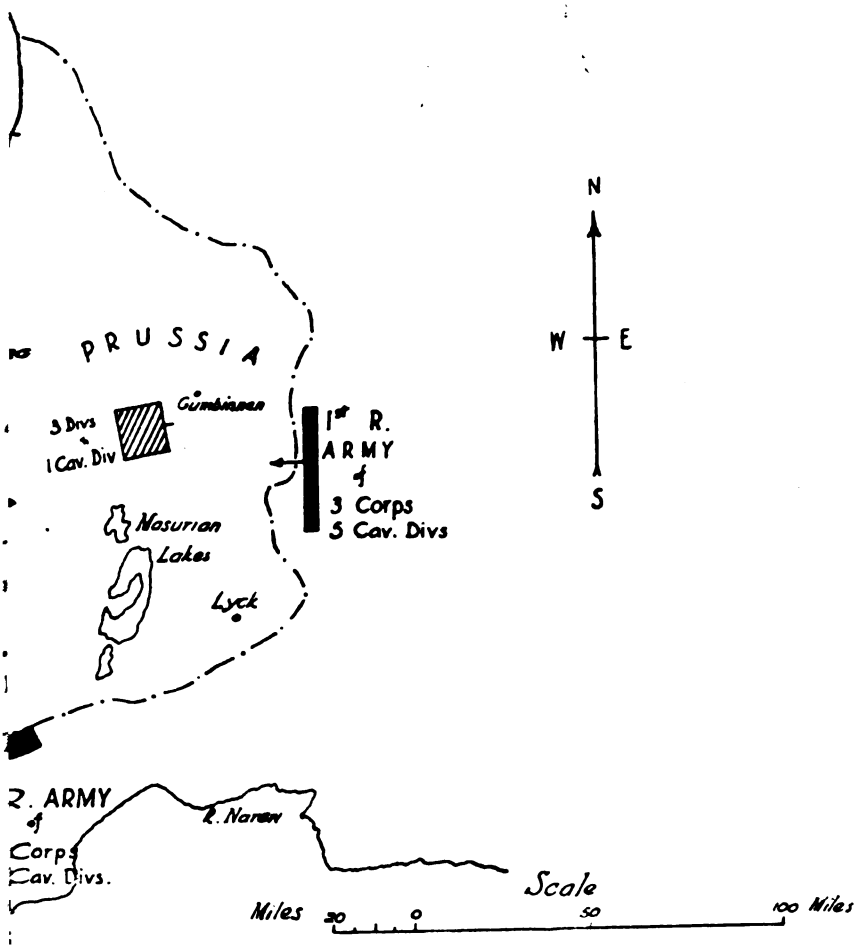
TANNENBERG CAMPAIGN.

Sketch "A"



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HISTORY OF THE 20th (FIELD) COMPANY; ROYAL BOMBAY SAPPERS AND MINERS.

GREAT WAR: 1914—1918.
(Concluded).

By MAJOR H. W. R. HAMILTON, D.S.O., M.C., R.E.,

" Acti labores sunt jucundi "

PART II.—MESOPOTAMIA.

JANUARY, 1916.

Basrah.—On the 7th January, 1916, the Company disembarked at Basrah, and moved on the 8th to Marghil. That night the camp was flooded by the overflowing waters of the Shatt El Arab—a foretaste of the future.

The next few days were spent in making arrangements for the march up-country. Rations were drawn, and kit and equipment renewed.

Arrangements were also made to leave behind the Maler Kotla Sappers, who henceforward formed a separate Imperial Service Company under their own officers.

The March Up-country. Map 6. On the 13th, the Company, leaving behind the Maler Kotla Sappers, started the march up-river, towing its equipment and thirty days' rations in " mahelas," as the native boats were called. Heavy rains fell; roads became impassable with mud; unbridged irrigation cuts had to be crossed; and more than once halts were necessary. Hence it was not until the 7th February that the unit rejoined the 3rd (Lahore) Division at El Orah on the right bank of the Tigris.

FEBRUARY, 1916.

General Situation. Map 9. Meanwhile the force, which was endeavouring to relieve Kut Al Amarah, had fought costly and indecisive actions at Sheikh Saad on the 6th and 7th, and at Orah on the 13th and 14th January, and had found further advance impossible after the unsuccessful attack on the Turks at Umm Al Hannah on the 21st of January. When the Company arrived,

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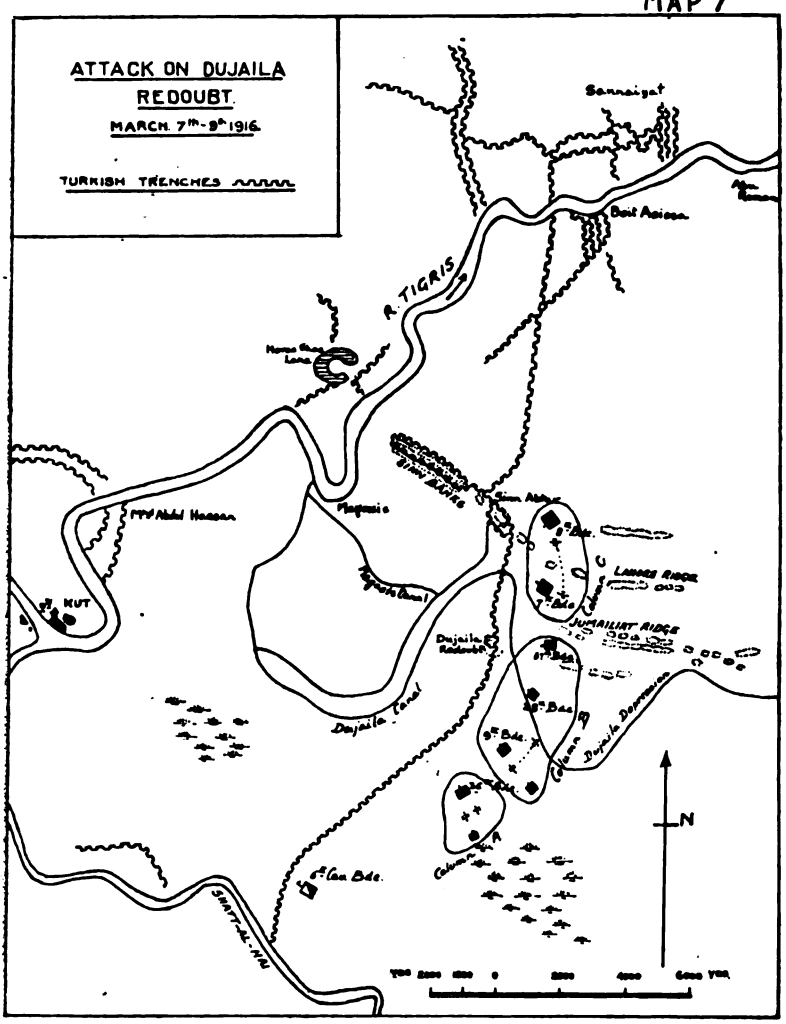
therefore, the Turks were still holding the strong position of Hannah, on the left bank, with the even stronger position of Sunnaiyat behind them. On the right bank they had weak forces holding the Sinn position, which was continued on the left bank astride the Suwada Marsh.

The right flank of the Turkish Sinn position rested on the Dujailah redoubt. This was a large mound some 200 yards in length, rising about 50 feet above the plain, and overlooking the country as far as Magasis, the site of the Turkish ferry. It was strongly fortified, but weakly held.

MAP 7



It was now decided to make a night march up the right bank and capture the Dujailah redoubt by a surprise attack. It was confidently expected that with this strong point in our possession it

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would be possible to join hands with the garrison of Kut, which still held a position on the right bank, up-stream of the Hai, at the Liquorice Factory (or Woolpress Village, as it was alternatively named).

The Company was now engaged in making up portable rafts and bridges, by which it was intended to cross the Hai. In addition, some dummy pontoons were constructed, and paraded ostentatiously on the river bank at Mason's Mounds opposite the enemy's line, in the hope of withdrawing his attention from the real point of attack.

Battle of Dujailah. Map 7. On the evening of the 7th March, the attacking columns moved out of camp. Captain Arbuthnot and 14 other ranks of the Company, all picked men, marched with " C " Column. The role of this party was to assist in the consolidation of the Dujailah redoubt, as soon as it fell into our hands. The remainder of the Company marched at dawn on the 8th, as escort to the transport. Immediately on arrival opposite the Sinn position at 11.0 a.m., the work of sinking wells in the Dujailah depression, an old bed of the Tigris, was put in hand. Meanwhile Captain Arbuthn ot and his 14 men, having made dug-outs for the Headquarters of the 3rd Division, joined the attack of the 8th Infantry Brigade on the Dujailah redoubt. The exact course of subsequent events was difficult at the time, and is more difficult now, to discover. It was understood that Captain Arbuthnot entered the redoubt, and was finally the only officer left, with details of the Manchesters and other units, to hold it against counter-attacks. It is certain, however, that he and his orderly, Sapper Hira Singh, were killed here, and eight others of the party wounded. So fell two brave men.

All attacks on the Dujailah redoubt having failed, it was decided to withdraw the force. Accordingly, on the 9th, the Company returned to Orah with the remainder of the attacking columns.

Major S. Boyd, R.E., now assumed command.

Sapping at Hannah. Map 8. It was now decided to take the Hannah position on the right by means of the deliberate methods of siege warfare. Accordingly, sapping was started on the 15th March. The 20th Company crossed to the left bank to assist, and took over two saps on the extreme right of the position. Work on these saps and their connecting parallels was pushed forward with the utmost haste. Whenever possible, men worked above ground, and sapper units vied with each other in their efforts to make progress. Though the Turks endeavoured to hinder the work by fire, by the action of patrols, and by putting out bomb-traps, by the 2nd April the line had been taken some 400 yards forward, and the advanced parallel lay about 100 yards from the Turkish lines During this period one Sapper of the Company was killed and two slightly wounded. The Company was congratulated by the G.O.C. 3rd Division on its work here.

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did not attempt to molest the water-parties. The "water-truce" was first broken by our snipers, who inflicted a few casualties on the enemy, and thereafter the river bank became unhealthy.

As the river fell, it became impossible to fill the Magasis Canal by natural means, and an oil-engine and pump were erected in an excavation in the river bank. This work continued until well into June.

Meanwhile Corporal Clark and the Company's first-line transport rejoined after nearly 6 months' absence, and the unit again became completely mobile. Captain A. Mason, M.C., R.E., and Subadar Ganpat Mahadeo, I.O.M., were invalided about this time, the former suffering from the effects of the heat, and the latter from cholera, which had been fairly prevalent in the force.

JUNE, 1916.

Water Supply at Abu Roman. *Map* 9. In June, the 14th Division relieved the 3rd Division, and the Company returned to the vicinity of Abu Roman, where it was employed until the 3rd August almost entirely on water-supply. This comprised the erection of pumps and engines, the construction of tanks, and the cutting of canals to take water to camps distant from the river.

JULY, 1916.

Leave was opened in July, and a proportion of men and officers proceeded on leave to India. 2nd Lieutenant Stables, I.A.R.O., joined during that month.

For a long time the men had been receiving rations deficient in fresh meat and vegetables, and the troops were now attacked by scurvy. In two months the Company lost 60 men suffering from that disease. Many of the best N.C.O's. and men were thus lost; and this sickness proved as hard a blow as many battles.

AUGUST, 1916.

Work at Twin Canals. *Map* 9. On the 3rd August, the Company marched to Twin Canals, and started the construction of redoubts, or block houses as they were called, to protect the new light railway-line from Sheikh Saad to Sinn Abtar. These posts provided cover for a small garrison; they were sited about 300 yards apart, and had an all-round field of fire, and the intervals between them were closed by an apron barbed wire fence. Alarms and flares were constructed in order to increase the difficulties of Arabs passing the blockhouse line at night.

In addition, much work was carried out at Twin Canals on water-supply, local protection of the camp, and communications. Moreover the fact that active operations would recommence in the autumn

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was not overlooked; Sappers, Pioneers and Infantry were practised in rapid wiring and trench-work.

Lieutenant Venables, I.A.R.O., left the Company about this time on being appointed Adjutant to the C.R.E., and Lieutenant Bowers joined.

As the season advanced the Arabs grew ever more and more bold, finding, it appeared, no difficulty in getting through the wire between block-houses, and carrying their depredations even as far as Divisional Headquarters on the river-bank. The Company, therefore, invented a bomb-trap, which held a Mills grenade. The latter was designed to explode when the wires of the fence were either raised or lowered. The work of fixing these began on the 1st November, and their presence undoubtedly deterred the Arabs from passing the block-house line nightly, as had been their custom. Lieutenant Hamilton was the first casualty, and had to go into hospital for a month; but an Arab was badly wounded a few nights later, though he escaped to warn his friends.

December, 1916.

Active Operations Commence. Map 9. On December 18th, the Company moved forward to Magasis, where it was attached to the 8th Infantry Brigade.

Meanwhile the operations, which were to lead up to the re-occupation of Kut and to the capture of Baghdad, had been started by the 3rd Corps (13th and 14th Divisions), which had moved forward on the 12th December to a position astride the Hai. The 3rd Division had at the same time advanced, and masked the Turkish position in the Muhammad Abdul Hassan bend.

Operations in which the 20th Company took part were now set on foot, with the object of squeezing the Turks out of the latter position.

The advance was deliberate, and carried out in methodical stages. Series of posts were pushed forward by night and wired, and connected together and to our old line, on succeeding nights. This continued until the advanced parallels were within assaulting distance of the enemy trenches. The work was hard, and sometimes hindered by enfilade machine gun fire from the left bank, but the Turks were less active than might have been the case. Night work in Mesopotamia was more trying than in France, as, owing to the clearness of the atmosphere, bodies of men could be distinguished easily on a moonlight night at 400 yards range.

January 9th, 1917.

The Attack. On the 9th January, 1917, the final assault position having been reached, two Infantry Brigades of the 3rd Division

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attacked the Turkish lines at dawn. Major Boyd, Lieutenant Bowers and 2nd Lieutenant Wardle, I.A.R.O. (who had joined on the 8th), with the left half-company, accompanied the attack of the right brigade, the 8th, with orders to consolidate the captured trenches.

There was a thick mist, and at 10.0 a.m., a Turkish counter-attack drove troops on the right from the captured trenches, and uncovered the flank of the Sapper working party. Parties of Turks started working down the trenches on the right; and as he had no bombs, Major Boyd decided that it was impossible to continue the work and retreated to our original position. By the time this had been accomplished, two men had been killed, and Lieutenants Bowers and Wardle, and fifteen others, wounded.

During the course of the day the Manchesters recaptured part of the lost line, and in the evening the whole Company was used to consolidate the position.

The Turks pressed out of the Bend. Thereafter the work of pressing the Turks out of the bend continued; and the work of the Sappers was hard and continuous. On the 19th it was intended to make a final attack on the enemy and round-up his remaining troops, who had only a ferry behind them, but they retired across the Tigris on the night of the 18th-19th. Patrols soon reported that the bend was clear, and the final attack did not take place.

The following were the casualties during these operations:—

Killed	4 Indian other ranks.
Wounded	2 British Officers and
	1 Indian Officer (Jemadar Uttam Singh).
	28 Indian other ranks.

FEBRUARY, 1917.

General Narrative. Map 9. Henceforward the Company was employed on almost continuous night work, building up the "bunds" on the river bank from the Muhammad Abdul Hassan bend to Magasis, and in strengthening the piquets which guarded this long line of river bank. Lieutenant C. R. Otto, R.E., joined the Company during this period.

Meanwhile the 3rd Corps had taken up the task of expelling the Turks from the right bank, and had captured Kala Haji Fahan and the Dahra bend by the 15th February.

On the 12th February, the Company moved to the left bank of the Hai, opposite the ruins of Kala Haji Fahan, and started work on the river "bunds" immediately opposite Kut. Here Lieutenant Bowers rejoined from hospital.

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Having completed the work in this neighbourhood, the Company moved to near Divisional Headquarters at Es Sinn on the 22nd, and the next day shifted camp a mile or two further to the rear.

The Shumran Crossing. Map 9. The 7th Division, after an unsuccessful attack on the 17th, captured the Sunnaiyat position on the 22nd, and, on the 23rd, the Tigris was crossed at the Shumran bend, and a pontoon bridge thrown across the river there, enabling the 3rd Corps and the Cavalry to cross to the left bank.

The Turks had now to march hard to escape complete envelopment

The Company Marches to Dahra. At about noon on the 24th February, the Company received orders to join the 8th Infantry. Brigade on the left bank of the Tigris above Kut, leaving behind 2nd Lieutenant Stables and No. 4 Section as a dump guard. Marching at 2.30 p.m., it crossed the river by the Sandy Ridge pontoon bridge, and camped near the 5th line of the Turkish Sunnaiyat position at 7.30 p.m. The march was continued at 6.30 a.m. on the 25th, and the 8th Infantry Brigade Camp at Dahra was reached at 1.15 p.m. the same day. A total distance of 35 miles had thus been covered in 23 hours. Not a man fell out, nor indeed did a single man fall out all the way to Baghdad, though many men, having only the bare vestiges of socks, marched practically the whole way barefoot.

This was the first time during the war that the men had felt the exhilaration of following up a beaten enemy.

March, 1917.

The March to Baghdad. Map 6. On the 26th February, the Company marched with the 8th Infantry Brigade, and reached Sheikh Jaad on the 28th, where it remained until the 4th March, improving roads and destroying Turkish ammunition. It then marched a few miles up-river to Baghailah, the former site of a Turkish bridge of boats, which the enemy had jettisoned. The material of the bridge was salved as far as was possible, and some Turkish guns, thrown into the river further up-stream, were hauled, not without difficulty, on to dry land.

Marching again on the 7th, the Company reached Bawi on the 10th, halting at Shidaif Ash Sharqi, Aziziyeh, and Zeur en route.

Between the 7th and 10th March, the Diyalah had been crossed by the 3rd Corps after heavy fighting. Baghdad railway station was occupied by the 7th Division on the 10th, and Baghdad itself entered on the 11th.

On the 13th, the Company marched to Hinaidi with the 8th Infantry Brigade, and next day, passing round to the east of Baghdad outside the city walls, went into camp at Muazzam.

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Operations on the Diyalah. The 15th March was spent in improvements to roads and water-supply; and on the 16th, the Company marched again with the 8th Infantry Brigade to Khan Bani Saad.

The column, to which the Company was attached, was intended to bar the retreat of the Turkish forces in Persia, via Khanikin and Qizil Robat; but its first objective was Baqubah, the site of a boat-bridge, where the Turks still held the left bank of the Diyalah.

On the 17th, the column marched to within a few miles of that town, which was situated almost entirely on the left bank of the Diyalah, and Sapper officers reconnoitred the river crossings below Buhriz, a village some three or four miles downstream of Baqubah.

That night the Manchesters and 59th Rifles were ferried across the river below Buhriz in pontoons. As there were very few of these the work was somewhat laborious. These two battalions then advanced up the left bank, and entered Baqubah, which the Turks had evacuated, while the remainder of the column marched to the site of the bridge at Baqubah. This had been broken, but a pontoon bridge was thrown across, supplemented by a short length of trestling on the left bank.

On the 19th, the column crossed by this bridge, and next day continued the march up the left bank of the river as far as Abu Jisra. On the 21st the march was continued, and the Turks were found to be holding a rear-guard position covering Shahraban, and commanding the Mahrut Canal, a rapid water-way about fifteen yards broad.

Shahraban. Map 10. *Bridging the Mahrut Canal.* Two sections were employed during the 21st and the night of the 21st-22nd in throwing a bridge across this canal about 350 yards up-stream of the old brick road-bridge, which had been demolished by the enemy. No pontoons were yet available, and local materials had to be used, extracted from some mud-hovels close at hand. The work was to a certain extent hindered by shell-fire; and rather a flimsy structure resulted.

The Company remained south of the Mahrut Canal on the 22nd, employed on minor jobs in the vicinity of the 3rd Divisional Headquarters, which had now arrived. The Turks now evacuated Shahraban; and on the 23rd, another trestle-bridge was constructed across the Mahrut Canal, while the 18th (Fd.) Company, 3rd Sappers and Miners, threw two pontoon bridges across the stream in the vicinity.

On the 24th, the Company moved to a point not far north of Shahraban, and immediately started a house-to-house search for bridging materials, which were, as will be seen, urgently required.

The Jabal Hamrin. The Turks were now occupying a position on the Jabal Hamrin, a range of intricate sandstone hills, covered by

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the Belad Ruz and Nahrunia Canals. They had destroyed the only existing bridge over the Belad Ruz, and, though pontoon bridges could be thrown across almost everywhere, the height of the banks necessitated much work on the approaches. The bridges actually made can be seen from Sketch Map 10. The 20th Company was responsible for only one bridge, the 18th Company for the remainder.

The British force now consisted of two Infantry Brigades, with Artillery in proportion, and some Cavalry; and, after some days of preparation, the bridges over the Belad Ruz and Nahrunia Canals having been completed, an attack was made on the Turkish position. The 20th Company did not take part in this action, but remained in camp collecting materials and repairing pontoons damaged by shell-fire. The attack was unsuccessful.

Subsequent to this attack a detachment of the Company was sent to prepare for demolition an ancient aqueduct over the Belad Ruz some nine miles east of camp, as it was feared that the Turks might counter-attack from that flank. This aqueduct was demolished on the 29th March. The Turks, however, having effected their withdrawal from Persia, began that night to retire from the Jabal Hamrin. This retirement was followed up by our troops as far as Qizil Robat, where a junction was effected with some Russian Cavalry.

Meanwhile the Company had remained near the Belad Ruz, and had by the 2nd April completed a single-sling bridge over that stream.

APRIL, 1917.

Return to Baghdad. The troops of the 3rd Division were now replaced by units of the 3rd Corps; and the Company marched back with the 9th Infantry Brigade, via Abu Jisra, Baqubah, Coningham's and Cassel's posts, to Baghdad, which was reached on the 7th April. Here camp was pitched on the right bank near the Railway Station; Lieutenant Stables and No. 4 Section rejoined, and Lieutenant Allen, R.E., joined the Company for the first time.

On the 8th, a short move was made to the vicinity of the Masudiyeh Canal, and the Company proceeded to assist No. 4 (Fd.) Company, 1st (K.G.O.) Sappers and Miners to construct a steel bridge. This bridge spanned a gap in the "bund" which ran from Baghdad towards Felujah. It was important to leave a clear water-way through the gap, in order to allow the escape of flood water collecting between the Tigris and Euphrates above Baghdad, and the bridge was necessary to carry the railway to Felujah.

At the same time the erection of a large aeroplane hangar was started.

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APRIL, 1917.

The Left Half-Company March to Samarrah. Map 6. On the 16th April, less the right half-company (with Lieutenants Bowers and Otto), the Company took the road again, and accompanied the 8th Infantry Brigade up the right bank of the Tigris, reaching the Median Wall on the 21st, where it was in time to witness, but not to take part in, the Battle of Istabulat. On the 23rd, the Company marched to Samarrah, and went into camp in the vicinity of the Railway Station—an extremely insanitary and fly-ridden spot.

The Adhaim. The Turkish force, which had been defeated at Istabulat, had meanwhile retreated to Tekrit. There was, therefore, no further need for large numbers of troops at Samarrah, and the supply difficulty was acute. Accordingly, the 8th Infantry Brigade, accompanied by the 20th Company—still without the right half-company—marched back by the right bank of the Tigris to Sinijah, and, crossing there by a pontoon bridge, reached Barurah on the 25th, after two trying marches. The role of the Brigade here was to hold the confluence of the Adhaim and Tigris, and secure the communications of the troops of the 13th Division, who were about to advance up the Adhaim and attack the Turkish force on the upper reaches of that tributary.

Remarks on Railway Demolition. A digression perhaps is permissible here, owing to its interest to any who may have to undertake the demolition of a railway. On leaving Samarrah, where they had collected practically all the locomotives and rolling stock of the Baghdad-Samarrah Railway, the Turks decided to render all the engines useless. They, therefore, went down the long line of idle locomotives and blew off the cylinders all along one side. Fortunately for us, they did not notice in their hurry that the engines were facing in both directions; and it was, therefore, easy for our railway engineers to make at least some engines serviceable by replacing damaged cylinders with serviceable ones from the unattacked sides. The line was running again in a surprisingly short time, though the enemy wireless strenuously denied that this could be possible.

Major Boyd proceeded on leave to India from Barurah and Lieutenant Hamilton assumed command.

MAY, 1917.

The left half-company remained in the vicinity of Barurah, throwing up defences for the Sinijah bridge-head, until the 8th May, when it marched with the 8th Infantry Brigade by the left bank to Samarrah, and, having crossed the river there, marched to Sumeichah, some 37 miles down stream from Samarrah, arriving there on the 13th.

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A heavy blow was dealt the Company on the last stage of this march, from Balad to Sumeichah, in the loss of 2nd Lieutenant Stables, who was marchingwest of the railway line, parallel to and some miles distant from the column, reconnoitring the country for a new road. He and his escort of 20 men of the 47th Sikhs were attacked by Arabs and all lost their lives. Their bodies were recovered and buried next day.

During the ensuing few days the quarter of Sumeichah, owned by the semi-nomadic tribe responsible for this attack, was demolished. Several Arabs were caught, of whom two were publicly hanged. An expedition organised to surprise the offending tribe, which had taken refuge in the desert about 10 miles west of the railway, was only partially successful. The left half-company formed part of one of the two columns, which moved by night on the enemy camp, and at dawn had reached its allotted position. The other column, which should have barred the retreat of the enemy, did not quite succeed in doing so, and the majority of the tribe escaped, pursued by gun fire, with the loss of a quantity of live-stock and other loot.

After a short stay at Sumeichah, improving the brackish and unpalatable water-supply, and taking up a branch railway line at Khor Tarmiyeh, a few miles away, the half company moved back to Balad on the 20th May.

" Breakdown " Work near the Median Wall. On the 22nd, another move was necessary to a point on the railway-line between the Median Wall and Harbeh, where a serious derailment had occurred. The work of clearing and relaying the line, and replacing a 112-ton engine on the track, under the direction of railway engineers, occupied the half-company until the 31st May, when it returned to the 8th Infantry Brigade camp at Balad. During this period a punitive expedition was undertaken by the Sappers and a detachment of the Manchesters to a village about 4 miles away on the bank of the Tigris, to round up a section of the tribe responsible for the death of 2nd Lieutenant Stables. No men were caught, but some tents were burnt, and 200 head of live-stock and a few hostages from a " friendly " tribe were brought back to camp.

Meanwhile the right half-company under 2nd Lieutenant Otto had arrived at Balad on the 28th May, and the Company was now complete again. Lieutenant Bowers had been transferred to the Irrigation Department.

The right half-company, during the period of its detachment after the completion of the aeroplane hangar, had been employed practically continuously in closing breaches in the " bunds " between Baghdad and Felujah. The work had been hard, and the breaches were only closed after many anxious moments, and with great difficulty.

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The Company remained in camp at Balad until the 23rd August, working on water supply and hutting in the 8th Infantry Brigade area, which included Harbeh and Sumeichah. The heat became intense during June and July, and temperatures of 128° F. in the shade were recorded. All troops, however, were provided with E.P. Tents; rations were good, and there was surprisingly little sickness. The men were kept interested by means of weekly Brigade race-meetings or athletic sports, in which the Company was most successful, and polo was organized for the officers.

During this time Sapper officers carried out reconnaissance of the Tigris and its fords, as far up-stream as Istabulat. In addition, as opportunity offered, the men were drilled and trained, and the Infantry instructed in trench warfare. In spite of the extreme heat, therefore, there was little time for idleness.

Lieutenant Nicolle, I.A.R.O., joined the Company on the 11th August.

Istabulat. On the night of the 23rd-24th August, the Company, less Lieutenant Nicolle and No. 1 Section, who were left at Balad to complete water supply work, marched to Istabulat. After preparing water supply for the 8th Infantry Brigade here, work was started on the Istabulat position. This formed part of Sir Stanley Maude's scheme of defence against the Turkish Yilderim (lightning) Army, in the event of the latter attempting to recapture Baghdad. Actually most of the Yilderim Army went to Palestine, and was there destroyed.

On the 7th September, No. 1 Section rejoined from Balad, and on the 13th, Major Boyd, R.E., rejoined and re-assumed command.

The general scheme of the Istabulat position included two tactical bridges over the Dujail Canal to take the heaviest loads. The roadway was carried on trestling, which had to be of a considerable height, and these bridges were not finished until the end of October.

On the 23rd October, the 8th Infantry Brigade received sudden orders to march to Samarrah, owing to the enemy having approached the 7th Division's positions at that place. The Company was left behind at Istabulat, and did not, therefore, take part in the Battle of Tekrit, on the 4th and 5th November.

2nd Lieutenant J. G. Stevenson, R.E., joined on the 24th October.

The time spent at Istabulat was most enjoyable, as the weather became cooler in September, and was delightful in November. The river was close to the camp, and bathing and fishing could be indulged in. Two boats were also made, which afforded a certain amount of amusement.

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On the 19th November, having handed over the Istabulat position to the No. 3 (Fd.) Company, 1st (K.G.O.) Sappers and Miners, the Company moved forward to Samarrah, and went into camp on the right bank. Work was immediately started on the Samarrah position, which had been handed over by Engineers of the 7th Division, and continued at full pressure throughout the winter. By March a strong position had been constructed, complete with deep dug-outs, machine-gun posts, observation posts, command posts, dressing stations, and barbed wire.

As the winter advanced, the weather became cold and wet, as many as eleven degrees of frost being registered one night, but all ranks kept fit, and there was no real discomfort.

At exactly midnight on New Year's Eve, the enemy ushered in the last year of the war by dropping a number of aeroplane bombs, but there were no casualties.

FEBRUARY, 1918.

During this period much was done by the Divisional Staff to keep the troops fit and amused. A cross-country race was held in February for Company teams, in which the 20th Company secured first place. A combined team of the 18th, 20th and 21st (Fd.) Companies of the 3rd Sappers and Miners also competed in the final of the Divisional football tournament, but were beaten by a battalion of Gurkhas. In addition, race meetings and horse shows were held; and those in search of amusement could attend an open-air cinema, which gave nightly entertainments near the Company's lines.

MARCH, 1918.

The Samarrah Pontoon Bridge. In March, 1918, half a company was employed for a short time assisting a detachment of a 2nd (Q.V.O.) Sappers and Miners bridge-train on the pontoon bridge, which crossed the Tigris immediately opposite the town of Samarrah. Captain Hamilton had already been for some time in charge of this bridge. This half-company worked well under Subadar Sardar Khan, Bahadur, and was of the utmost assistance. The bridge caused some anxiety, as it was 500 yards long; the stream sometimes ran 8 knots; wind made the bridge rock alarmingly; rain made the roadway dangerous for mules; and the bridge had frequently to be cut, isolating the troops on the left bank from their supplies. Moreover, whenever the bridge was cut, as each of the 100 bays of the bridge used to take up an inch or so at the claws of the baulks, the gap used to widen by nearly half a bay, and the utmost difficulty was always experienced in re-forming the bridge.

MARCH, 1918.

The Company moves to Basrah. On the 21st March, the Company marched to Baghdad, which was reached on the 27th. Captain

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Hamilton had meanwhile been transferred to No. 5 (Fd.) Company, 1st (K.G.O.) Sappers and Miners, and 2nd Lieutenant Fratini (who had joined the Company on January 25th) to the Tehri Garhwal Imperial Service Sappers and Miners. The Company proceeded by train to Kut Al Amarah on the 31st, and thence by boat to Amarah, which was reached on the 5th April. Having entrained again, it reached Basrah (Makina Camp) on the 6th. Here Lieutenant Price, I.A.R.O., joined the Company, but was re-transferred to the Sappers and Miners depot when Captain Hamilton rejoined on the 4th May.

MAY, 1918.

Embarkation for Palestine. A Field Company is never allowed to be idle, and various works were carried out in and around Basrah during the unit's stay there. At length Lieutenant Allen, Sergeant Clark, 29 Indian other ranks, and all the transport, embarked in the S.S. " Theseus," on the 11th May ; the remainder of the Company following on the 21st May, first in the S.S. " Bandra," and then, having effected a trans-shipment at Fao, in the S.S. " Danube."

Resumé. The Company's period of service in Mesopotamia which had now ended, can in no wise be compared to its campaign in France. It might, at first sight, appear from this account that warfare in the former country consisted of long periods of inaction, interspersed with a few, and innocuous, bouts of active operations. But, while admitting that actual battle casualties were few, and that, from April 1917 until leaving the country in May, 1918, the Company hardly saw a shot fired in anger, in justice to the men it should be pointed out that Mesopotamia was for them no bed of roses. Officers in the summer of 1916, for instance, might get E.P. tents—the men lived in single fly 160-pounders. In the same year officers could sometimes obtain canteen stores—the men could get no fresh meat or vegetables and rotted with scurvy. But never once did the Company fail to do all, and more than all, that it was called upon to perform ; and it left Mesopotamia justly proud of its work, which was well described by Major General Keary in his farewell order quoted below :—

" On leaving the 3rd Division, I desire to record my appreciation of the splendid work done by all ranks of the 18th, 20th and 21st Companies, 3rd Sappers and Miners.

" The 20th and 21st Companies have been with the Division since its arrival in France, and with it have taken part in numberless battles of the first magnitude. Since the day on which they, in conjunction with the 47th Sikhs and 9th Bhopals, captured the village of Neuve Chapelle in October, 1914, to the Battle of Jebel Hamrin in March, 1917, these two Companies have held a

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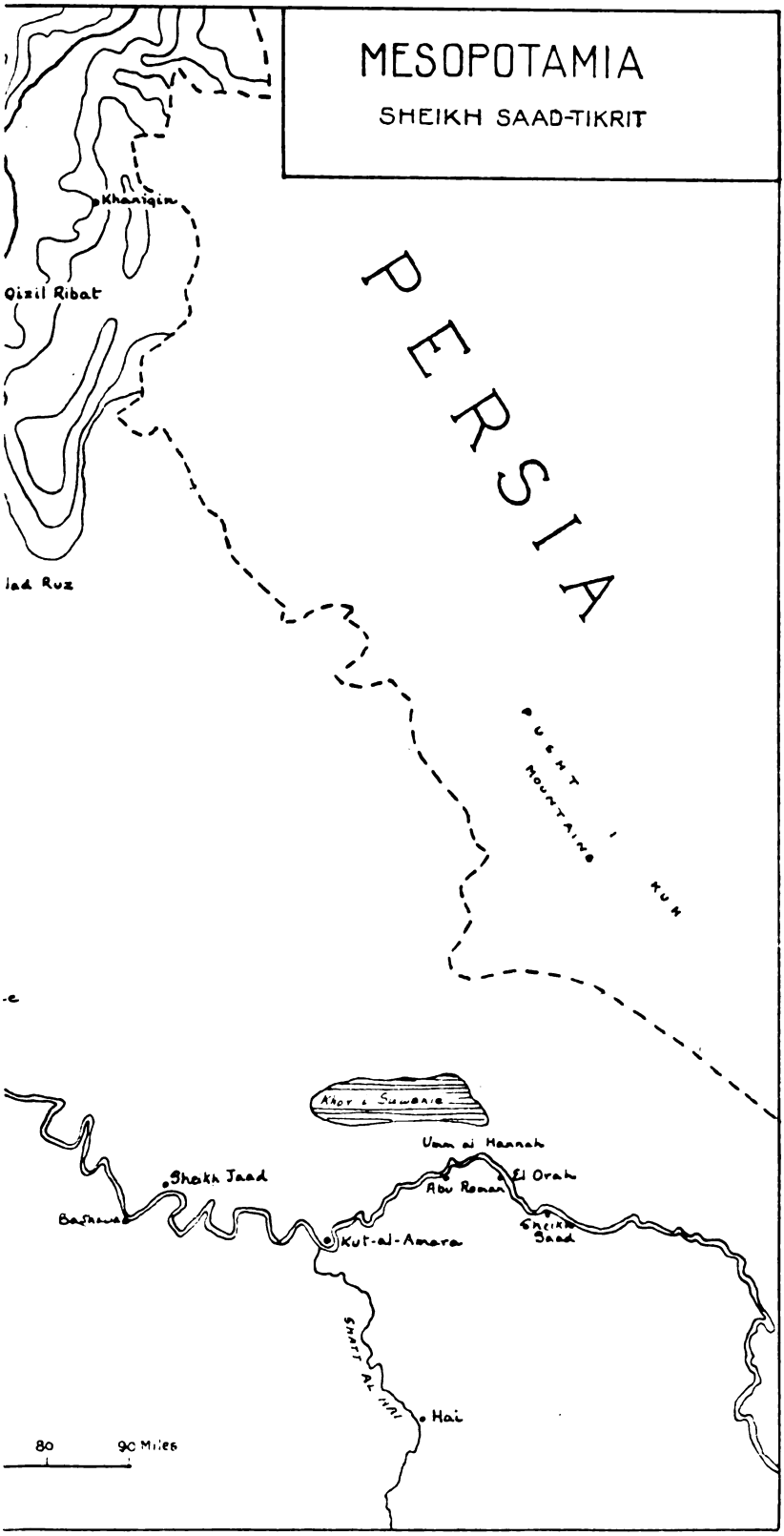
MAP. 6



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record for gallantry and fine fighting spirit second to none. Among other feats may be mentioned that of Captain Arbuthnot and his handful of men, who held the Dujailah redoubt to almost the last man against overwhelming odds.

" To enumerate all the fine achievements of these two Companies would be too long for the purposes of this order. Suffice it to say that wherever and whenever they have been called upon to assist in battle they have responded nobly.

" As Sappers their toil has been unceasing, by day and by night, digging, wiring, bunding, bridging, or sapping, all three Companies have laboured unremittingly under all conditions of enemy's fire, floods, heat, cold, and privations, with the utmost cheerfulness and zeal. No troops could have worked harder or such long hours, while the quality of the work has shown ingenuity and skill of the highest order."

Allowing for a certain hyperbole of language, this was not too high an estimate of the Third Sappers and Miners.

PART III.—PALESTINE.

Voyage to Suez. The S.S. " Danube " was an old ship, badly in need of repair and well packed with troops. Room was found, however, for physical training in the mornings; and detachments of the Company assisted in the stoke-hold. In addition, rowing drill was carried out in Muscat and Aden harbours. After entering the Red Sea, the old engines of the ship developed a habit of breaking down, doing so for the last time in a high wind at the entrance to the Gulf of Suez. Port was made at last, and all ranks were glad to disembark at Suez on the 9th June, whence they were railed the same day to Moascar, just outside Ismailia, where the transport rejoined.

Re-equipping at Ismailia. The Company was now re-equipped on the E.E.F. scales, which differed from those in force in Mesopotamia. For instance, water gear sufficient for a Brigade group was carried by a Field Company in the Egyptian Force, and proved invaluable. During their stay at Ismailia the men were brought into condition by constant route marches, and practice was obtained in loading transport and other duties.

Captain Hamilton now joined the C.R.E. as temporary Adjutant R.E.

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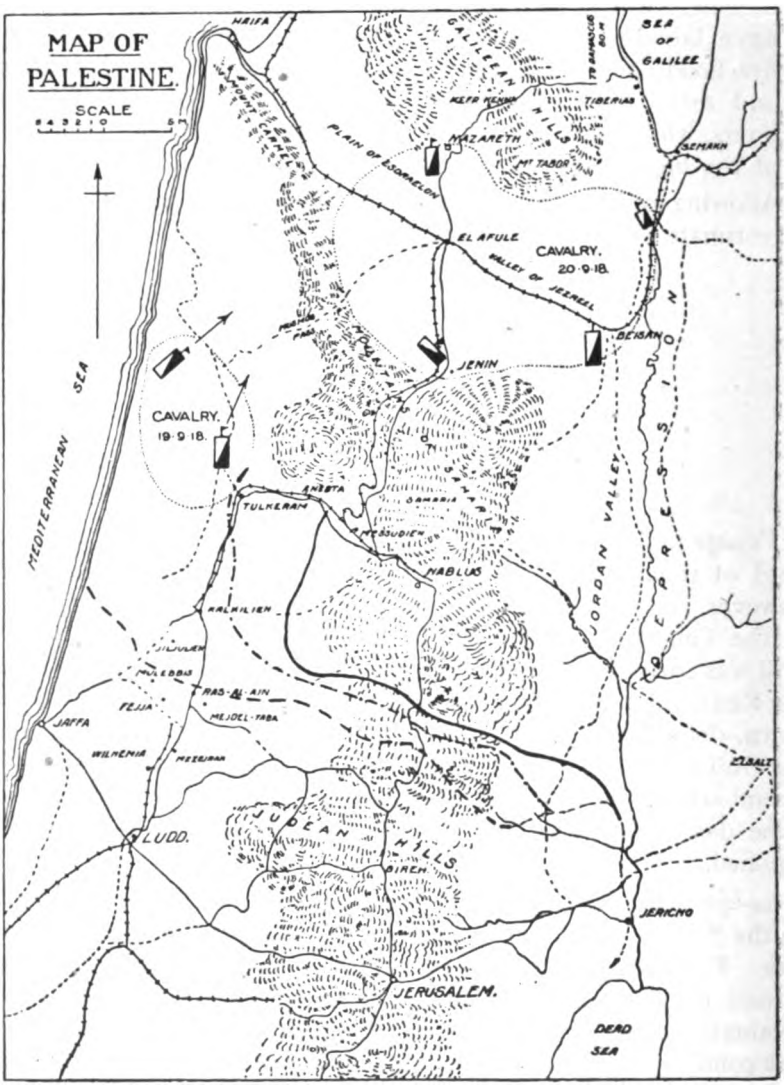
JUNE, 1918.

Move to Palestine. Map 11. On the 23rd the unit entrained for Ludd, which was reached on the 24th, and marched thence to camp at Wilhelma, arriving at 10.0 p.m.

The Company worked here on water supply, which included pipe-laying, and the construction of masonry troughs, reservoirs and bath houses, until the 8th July, when the left half-company moved forward and took over the defences in the 9th Infantry Brigade

MAP 11



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area, while the right half-company was kept employed in the neighbourhood of Mezeirah on water supply work.

2nd Lieutenant Pirie, I.A.R.O., now joined the Company vice 2nd Lieutenant Stevenson, R.E., who was transferred to the 18th (Fd.) Company, 3rd Sappers and Miners.

Mejdel-Yaba. On the 15th July the Company moved camp again, and concentrated for work on the Mejdel-Yaba sector. Mejdel-Yaba was a conspicuous village on a foot-hill overlooking the plain, which stretched some 10 miles from the mountains to the sea. It was, therefore, a favourite target for the enemy gunners, and Lieutenant Nicolle was slightly injured here, and a sweeper (who had accompanied the unit to France) was wounded by shrapnel. Work on the defences in this area continued by day and night until the 29th July, when the unit moved via Mulebbis, across the river Auja, to Fejja, and took over work from No. 3 (Fd.) Company, 1st (K.G.O.) Sappers and Miners of the 7th Division.

July to September, 1918.

Fejja. The Company remained in bivouac at Fejja until the 18th September, working continuously on water supply, communications, bridges, and defences. These were designed partly for present needs, but more particularly with an eye to the offensive which was now being prepared. Though this bivouac was in full view of a Turkish O.P. in the foot-hills, it was not shelled and the Company only sustained two casualties: a Sapper killed on night-work and 2nd Lieutenant Pirie slightly wounded.

Captain Hamilton now rejoined from duty with the C.R.E.

The weather, though warm, was delightful; the country was pleasantly green; the Turks were inoffensive; and news of fresh victories in France was received almost daily. So much so, that these two months were perhaps the pleasantest spent by the Company during the war. At any rate, the orange groves of Mulebbis and Jaffa compared favourably with the empty plains of Mesopotamia, and leave to Cairo and civilization could easily be obtained.

September, 1918.

The Final Offensive. *Map* 11. On the night of the 18th September the Sappers cut gaps in our wire to enable the attack to pass, and on the 19th at 6.15 a.m., immediately the first objectives had been captured, advanced to Kalkilieh, about 6 miles in the rear of the enemy line, and there developed the water supply. A continuous stream of men and animals were watered here during the afternoon and evening.

7 Indian other ranks were wounded this day by the explosion of some Turkish bombs. The camel which stepped on the bombs and ignited them remained unhurt.

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20TH SEPTEMBER.

Advance into the Hill Country. Next day, leaving behind Captain Hamilton, the wheeled transport, and No. 3 Section, the Company struck off right handed into the hills, with the advanced guard of the 9th Infantry Brigade, by way of Jiyus and Khan Sir to Baka, where men and animals were watered, and the enemy seen in retreat along a road running north-east from El Funduk. Continuing the advance to Kuryet Hajja, the Company was ordered to occupy a defensive position on some high ground, to withstand a reported counter-attack, which did not eventuate. Having been relieved later by the 93rd Burma Infantry, the Company returned to Kuryet Hajja, and improved the water supply, bivouacking there for that night.

Advance to Nablus. On the 21st the march was resumed past Kuryet Jit along a road strewn with enemy impedimenta, and finally by mountain tracks to Rafidieh, a village on the outskirts of Nablus, overlooking the Vale of Shechem. Here the Company halted until the 23rd, developing the water supply. On the latter date the Brigade Commander of the 9th Infantry Brigade addressed the Company, informing all ranks of their splendid success and thanking all for their share.

The advance had indeed been trying, as it had traversed a rough hill country, with little water and bad roads. For two days the men had existed on their emergency rations and on what they could find. Luckily, large Turkish supplies were found near Nablus.

Meanwhile No. 3 Section and the transport had marched by the narrow valley of the Wadi Azzun, reaching the neighbourhood of El Funduk late on the night of the 20th-21st. They were ordered by the C.R.E. of the 3rd Division to develop the water supplies of the Wady Kana, which lay to the south of the Wadi Azzun, and, having done so, they marched on the 22nd via Kuryet Jit to Zawata in the Vale of Shechem, between Nablus and Samaria.

Messudiyeh. At 2.0 a.m. on the 24th September, the Company marched to Messudiyeh, picking up No. 3 Section on the way, and, after a short stay there, developing water supply and improving roads, moved by Anebta to Kakon, which was reached on the 26th.

The Return to Jiljulieh. It was confidently expected that the 3rd Division would now move up into Syria by the coast road, but at the last moment the orders were changed, and the 7th Division went instead. The Company, therefore, marched back to Jiljulieh, where it remained until the 9th October.

Lieutenant E. H. Silcock, R.E., 2nd Lieutenant Le Quesne, R.E., and 2nd Lieutenant Spence, R.E., joined the Company here.

A further move to Mejdel Yaba was made on the 10th October,

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and the Company was thereafter employed, strung out along the Wadi Ballut behind the former British line, salving wire and pickets, and destroying dangerous explosives. Here 10 men were wounded by accidental explosions, 7 of them by the explosion of live bombs on a Gunner wagon. The Company conscientiously salved many miles of barbed wire, which, however, could still be seen in 1920, and probably to the present day, stacked and rusty near Ras Al Ain.

After completing this job, a few days were spent in training, and then the Company returned to Jiljulieh, where Major Boyd and Lieutenant Nicolle left the unit to form new Sapper and Miner Companies at Kantarah. Captain Hamilton now assumed command and Lieutenant Pearce joined from the 18th (Fd.) Company, 3rd Sappers and Miners.

The March to Tiberias. The Company then received orders to accompany the 9th Infantry Brigade to Damascus, and marched on the 25th October, a day ahead of the column, via Tulkeram, Zawata, Jeba, Jenin, El Afule, Reineh (North of Nazareth), to Tiberias, developing the water supply at each halting place. Tiberias was reached on the 4th November. Here orders were received that the 21st (Fd.) Company, 3rd Sappers and Miners, which had suffered badly from malaria at Semakh, at the southern end of the Sea of Galilee, would proceed with the Brigade to Damascus, and that the 20th Company was to relieve them at Semakh, where the 7th Infantry Brigade was camped.

Semakh. Semakh was reached on the 6th, and water supply and other work undertaken there. The 7th Infantry Brigade then received orders to return to Ludd, and the Company marched ahead of them on the 9th by the direct route across the mountains to Kefr Kenna, where arrangements were made to water the Brigade, which marched by Tiberias and arrived on the 10th.

Nazareth. On the 11th November, the Brigade moved into Nazareth, where the Company occupied leaky billets overlooking the town from the north.

Heavy rains now fell and were not deterred by the roofs of the billets from flooding all the rooms, and drenching the occupants. The next few days were, therefore, not enjoyable, notwithstanding the fact that the news of the Armistice filtered through to the Company on the 13th. As far as the Company was concerned there were no armistice celebrations, and the news was soberly received.

Conclusion. Here the war-history must end. There was much work throughout the length and breadth of Palestine, from the

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shores of the Sea of Galilee to Beersheba, and from Ludd to the banks of the Jordan, still in front of the Company. The old officers were to go and new officers were to take their places. Nearly two years of exile and discomfort were to elapse before the majority of the men were to see their homes. But yet the spirit of the Comp ny and the Corps lived on. And it was still a fine body of men, worthy successors of the men of 1914, who on the 17th August, 1920, marched proudly across Holkar's bridge, and swung on to the Sapper parade ground, at Kirkee. Here, together with the 21st (Fd.) Company, they were received with all honour by the Corps, at the head of which was Major Paris, their former Company Commander. Just six years before, on that same ground, the Company had promised him that it would strive to add something to the Scroll of Honour of the Third Sappers and Miners. Let this history show whether that promise was fulfilled.

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DIVISIONAL ENGINEERS OF THE FUTURE— THEIR DUTIES AND EQUIPMENT.

By MAJOR-GENERAL G. WALKER, C.B., C.B.E., D.S.O.

THIS article has not been written in order to lay down anything dogmatically, but, rather, to raise discussion and to suggest some lines of thought. Everything, including units of Divisional Engineers, has to change to meet the exigencies of changing circumstances. It is interesting in this connection to reflect upon the days when Field Units R.E. were non-existent. It is not so long ago, either. The first units of field character to emerge from the gloom were the Bridging and Telegraph Troops. Then it was realised that the common foot-slogging sapper, whose officers did not wear red shell jackets and sabretaches, also required some means of transporting his technical equipment. The result was the introduction of another mounted R.E. Troop ; its vehicles were loaded with R.E. stores and its officers were entitled to wear the coveted jacket and sabretache also.

Let no one think that I am here casting derision on these emblems of military glory. Far from it ; they were the outward and visible sign of the military efficiency and grace of the wearers, and I may say that I once wore, with, I hope, becoming humility, a sabretache myself. As time went on, the store Troop was split up between certain foot companies, and the ancestor of the present Field Companies was born.

I think this *resumé* of the evolution of the present Divisional Engineers is interesting, seeing that the " Bridgers " and the Telegraph unit have passed away and that the Field Company, the Cinderella of the three, alone remains extant.

As things have changed in the past, they will assuredly do so in the future. Our problem is, can we foresee how ?

2. I take it that no one will quarrel with me when I say that the office of the Divisional Engineer is to apply his art in such a way as to facilitate the other arms in getting to grips with the enemy. That broad definition covers a great many things. It is operative alike in attack and defence, in advancing as well as in retreating. It covers protection from fire and from weather, reconnaissance, communications, both from a constructive and a destructive point of view, and obstacles, as regards both their creation and the overcoming of them.

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3. It is desirable, however, to sort out these various duties more definitely. There is one of them which in war is incumbent upon everyone, that is reconnaissance. The Sapper must not confine himself to R.E. reconnaissance, although that affects him possibly most nearly. He must help, with others, to collect, sift, and transmit all the information he possibly can, and he must do this bearing always in mind the sort of news that other people are looking for.

Again, it is now generally, anyhow officially, accepted that the R.E. is only required to do what other people cannot do for themselves. He is, consequently, not expected to dig other people's trenches, nor to put up wire for them. This fact will facilitate, but not reduce, his work, for he will now have time to think about and execute work which was out of his power before.

In view of the above, the work of the Divisional Engineer will probably be of the following classes :

(*a*) Reconnaissance for himself and others.
(*b*) Clearances of fields of fire.
(*c*) Obstacles.
(*d*) Preparation of elaborate defences in stabilised positions
(*e*) Bridging.
(*f*) Demolitions
(*g*) Water supply.
(*h*) Protection against weather.
(*k*) Communications.

4. In modern war, after rapidity of thought and decision, rapidity of action, whether as regards mobility or speed of work, is the first essential. It is no use thinking of the right thing if the other man does it first. The man who gets a move on first has 6 to 4 the best of it in either peace or war.

5. Having spoken generally so far, the next best question is, how are we to produce this speed ? Up to the present we have relied upon man power, manual labour, only, for our work close up to the enemy. We are in exactly the same position in this respect as we were at the time of the Crimean War, or, perhaps, even further back than that. Is it not possible that the progress in the arts of peace has produced things that will strengthen our hands, or possibly enable us to do without them to a large extent ? In short, could we not largely mechanicalize our equipment ? I believe it is possible and also desirable.

6. To go a step further :

(*a*) *Reconnaissance.* Is there any equipment possible that would help the Divisional Engineers to assist the Survey units ? I do not know, but I should like to, as the accuracy, completeness and rapid production of the work of the Survey Department is of immense advantage to the engineer in war.

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(*b*) *Clearances.* Is there nothing new in mechanical invention that will supersede the cross-cut saw and axe, or tree cutting by explosives, and which at the same time would be suitable for the equipment of a mobile unit ?

(*c*) *Obstacles.* The most important are tank obstacles. Apart from land mine fields, which it is understood are under consideration, we have not much power at present. Power-driven earth borers, or augers and diggers might help us to produce more substantial overground obstacles than can be produced with mauls and crowbars.

(*d*) *Elaborate Defences.* These connote mining and deep dugouts among other things. Mining may possibly be outside the sphere of the Divisional Engineer, although I have had to do it, both as a Field Company Commander and as a C.R.E. of a Division. Mechanical diggers, as used in civil life, or modified, would be of the greatest help.

(*e*) *Bridging.* It is possible, with the advent of heavy mechanical traffic close up to the front, that the field companies may not be capable of undertaking all the bridging, and that the old " Bridger " may reappear, although shorn of his gay plumes. If not, field companies would be greatly helped if they had some power-driven gear for lifting heavy weights.

(*f*) *Demolitions.* As these were understood in 1914, they were of a most rudimentary character, for we never had a scheme, and even if there had been such a thing we never had enough time. At Mons, the demolitions were carried out under fire, and by the time we got to the Marne we had no explosives left. Military demolitions to be effective must be carefully considered engineer operations, not haphazard efforts to carry out the ideas of the moment. When decided upon, there must be means for rapid preparation and execution. We all know the difficulties of attacking concrete or masonry piers with hand tools. The usual results of any efforts in this direction are unsatisfactory unless a lot of time is available. A power-driven drilling plant seems within the bounds of possibility, and is certainly most desirable. Complicated steel girders are also a tedious and difficult matter to deal with by explosives, and it seems reasonable to suppose that some use could be made of the oxy-acetylene flame in this connection. Again, in repair work it is a question if the use of oxy-acetylene welding is too much for a field company if it could have a portable plant.

(*g*) *Water Supply.* The principal need in a field company is, as far as my experience goes, a power-driven pump in addition to the hand pumps. There ought to be something in civil life to meet this need. We do not look for the perfect article, that probably only exists in some vivid imagination, but we do want something that will " do." Power for driving tube wells would also be a great help.

(*h*) *Protection against the Weather.* This covers huts, canvas shelters, etc., as most of us realise that anything is better than the

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sky for a covering in cold or bad weather. It should be clearly understood, however, that troops cannot expect protection of this character from R.E. sources except in stabilised situations.

A field unit now has to compete with this problem by manual labour. Machine saws for cutting scantlings and boarding, and a mechanical feller for cutting down trees, would be a great help. It may be argued that in stabilised positions a field company would not be asked to do this work, which would be carried out by Corps or Army R.E. At the same time the force may be so small as not to merit the name of an Army, or even a Corps: What then? It seems desirable that, anyhow, we should have something of the sort available for issue when wanted.

(*k*) *Repair of Roads.* From the point of view of the Division, this, except in special cases, is a manual labour job, unless corduroy or slab roads are wanted. Repair of road bridges is, however, a different matter, and some sort of lifting gear for launching temporary or repaired girders would be of great use.

We now come to the question of the actual mobility of the units and sub-units. At present we depend upon the horse and wheeled vehicle. Is this good enough? Is the horse sufficiently mobile, and can the wheels go everywhere they are wanted? I am afraid not. I believe we ought to have petrol-driven vehicles which will be independent of roads, for both the sub-units and the stores of the field company—vehicles of the "wheel or track convertible" variety. These vehicles should be designed, not only to carry equipment, but at least some of the men also. This last is a reasonable demand, and will be understood by all who have marched a company of sappers from daylight to dark, and then had to put them to work all night. I often wondered how the men did it. If we are to get the ideal rapidity we must have rapid-moving transport, some means of conserving the energy of the men, and such power-driven mechanical devices as are possible, so that the men can do their work, when they get to it, with speed.

7. The suggested petrol-driven vehicles could provide the power when at rest for the power-driven tools. If fitted with winches, and possibly a light jib, it would be all to the good. In addition to the vehicles mentioned above, the provision of motor-cycles and side-car combinations would be of great assistance, even in the present horsed units.

8. For work at night, the provision of a small lighting set with shaded lights would be a great help in each section of a field company. While on the subject of electricity it is worth considering whether W/T. in a field company is desirable. Before 1914 we had visual signalling, and we sent men to the Army Signal School to be trained. A man waving a flag or flags during the Great War was more likely

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to qualify for promotion to the next world than in this, so the flags were put away. If inter-communication was necessary before the war, it would appear to be not less so now.

9. My critics will say, no doubt, that this article is largely "hot air;" that nothing is recommended with any exactitude. It was not intended to be exact. What is intended is that we should, as a Corps, start thinking about these things. It is easy enough to write about the past and one's own experiences. It is not so easy to look forward and think clearly about the future. Engineering science is advancing every day, and it is our duty to see how we can use the inventions of the day for the good of the service. It is "up to" all of us, no matter how young we may be, to use our opportunities in this matter and to give expression to the results of our enquiries in writing, presumably in this journal. It is no use to be afraid of being derided for our youth and inexperience. Youth is a disease that Nature quickly cures. Youth also has this great asset: It is buoyant and usually free from the trammels of tradition. Moreover, the youth of to-day will have to run the show in the future; in fact, the future lies with them. I hope that these lines, if they do nothing else, will raise discussion and will induce people to bring forward definite technical suggestions, not mere pious aspirations, on this most important subject. It is not *lèse majesté* to do this. The military authorities have to make the decisions, but it is not *ultra vires* for any one to make suggestions that may help those decisions to be wisely made.

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THE DISEMBARKATION AT ALHUCEMAS BAY.

The following account of the Spanish disembarkation in the bay of Alhucemas (Morocco) in September, 1925, is abridged from a detailed narrative by Captain D. Joaquin Ramirez y Ramirez, of the Engineers of the Spanish Army, in his Corps magazine for the month of March, 1926.

By LT. COL. R.E.M. RUSSELL, C.B.E., D.S.O., R.E.

THE operation had been considered since 1912, and would probably have been carried out in 1921 had not the disaster of Annual in that year paralysed the Spanish campaign until the entry of France into the combat, in 1924, gave it new life.

The plan adopted in 1925 was drawn up by General Gomez Jordana, and was destined to take place in June of that year, but for various reasons was postponed until the beginning of September.

The objective was Axdir, the seat of the Rifi Government, and the hinterland of the Alhucemas coast, which was the main landing place for Rifi war material obtained from Europe.

Information as to the Rifi strength and dispositions is not given, but is stated to have been good. They appear to have been in considerable strength, well supplied with artillery and machine guns, and their morale was high. They were expecting attack from the shores of the bay of Alhucemas, and had disposed most of their available infantry and artillery accordingly, as well as having laid submarine mines off the coast, and obstacles on the land approaches.

The Spanish plan was to effect two simultaneous surprise landings on opposite sides of the Bocoya peninsula, which was well outside the prepared zone; establish a base on the peninsula, and advance as rapidly as possible by successive bounds to Rocosa, Adrar Seddum, and the final objective at Axdir; the real landings being preceded and accompanied by bombardments and simulated landings at places within the zone of the enemy's preparations. In addition to the factors of surprise and tactical security thus aimed at, it was hoped to obtain the easy submission of the Bocoya tribe, who were not on the best of terms with the Beni Warrigel. Adverse factors were the scarcity of water, supplies and fuel on the Bocoya peninsula, with the consequent danger in the event of prolonged bad weather on the exposed beaches.

Forces available.—The Spanish forces available for the landings totalled 20,000 of their European and Native Regular Army, Foreign Legion ("Tercio"), and native auxiliaries; including 24 guns 7 c/m. or (2.8 inch) and 10 5 c/m. (or 4.2 inch), 100 machine guns, 133

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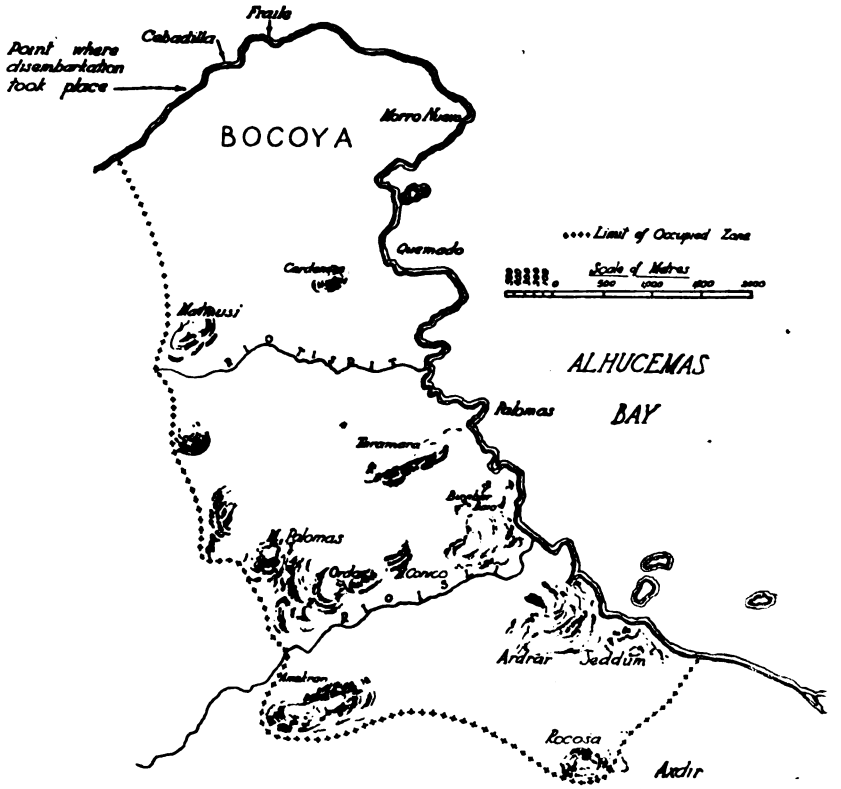
light automatics and 40 trench mortars. The whole organized as a "division" of two "columns" (or brigade groups) of all arms. The Spanish and French Fleets provided a battleship, 4 cruisers, 6 gunboats, and minor craft, mounting in all 28 30.5 c/m. (12 inch), 35 15 c/m. (6 inch), 22 14 c/m. (5.5 inch), 46 10 c/m. (4 inch), and 23 7.5 c/m (3 inch) guns, in addition to anti-aircraft and machine guns.

Air force units, Spanish and French, naval and military, provided theoretically 100 aeroplanes and some kite balloons, but the author states that the number which actually materialized were "much fewer."



The 1st Divisional Commander, General Sanjurgo, was in supreme command of all the naval, military, and air forces until the disembarkation of the troops was effected, when the command of the fleet was to revert to the Admiral.

The two columns (or Brigades) were known as :—

(*a*). The Melilla Column, under the command of General Fernandez Perez, allotted to the landing projected at Cala del Quemado (on the S.E. side of the peninsula).

(*b*). The Ceuta Column, under the command of General Saro, allotted to the landing at La Cebadilla (on the N.W. side of the peninsula).

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The columns were of approximately equal strength, each having about :—

4 Battalions European Regular Infantry (including one Marine Battalion).
2 Battalions Foreign Legion (Tercio).
3 Battalions Native Regular Infantry.
1 Mounted unit of Native Auxiliaries.
1 Dismounted unit of Native Auxiliaries.
1 Artillery Group (1 six-gun battery 2.8 in. mountain guns and 1 six-gun battery 4.2 in mountain howitzers).
3 Companies Engineers.
Medical and Administrative Services.

Each Brigade was given 11 transports and a hospital ship. In addition, the Ceuta Brigade (Cebadilla landing) had an extra ship carrying a battalion and bridging stores. A reserve hospital ship accompanied the Melilla Brigade.

In each Brigade 2 transports carried ammunition, 2 engineering stores, 2 camping material, 2 supplies, 1 animals, 1 medical stores, and 1 reserve stores.

For transport from ship to shore there were available for the two landings, in addition to the ships' boats, 26 motor-driven "K" lighters (those actually used by the British forces on Gallipoli), each carrying 300 men, drawing about 4 feet of water, and provided with a let-down bow extending some 26 feet.

The engineers carried material for constructing 8 landing piers, each about 100 feet long, as well as pontoons. (The Spanish pontoon is of steel construction, and fairly good in rough water).

One hundred civilian professional boatmen were allotted to each landing.

Rifle Ammunition.—200 rounds on the man.
50 per rifle in the lighters.
250 in boats.

A reserve of one million rounds per Brigade was carried in the reserve store ship.

Light Automatics.—2,000 rounds with the gun, 400 per gun in the lighters, 1,600 per gun in the reserve store ship.

Machine Guns.—7,800 rounds with the gun, 3,900 in the lighters, 11,700 in the reserve ship.

Grenades.—4,000 hand and 5,000 rifle per brigade, of which 250 were in each lighter and the remainder in reserve.

Artillery Ammunition.—(Nature not stated ; presumably all H.E.) per 7 c/m. gun, 144 with the battery, 432 in reserve store ship ; per 10.5 c/m. Howitzer, 112 with the battery, 336 in reserve store ship.

Field Engineer Stores.—4 sandbags on each Infantry soldier, 1,000 in each lighter.

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Sandbags and obstacles for 5 company posts and 12 platoon posts for each brigade in the reserve store ship.

Two 45 c/m. searchlights per brigade.

Water.—Each man carried two water bottles. The lighters and boats carried their own receptacles full and in addition 170 portable carriers, each holding 14 litres, 400 tanks, each of 300 litres and 2,000 casks of about 20 litres. Three tank boats of from 70 to 300 tons capacity were available. Pontoons were also counted on as supplementary water carriers if not otherwise required. A special engineer water-boring unit was provided for each brigade.

Supplies.—Two days preserved meat and bread on the soldier, 2 days ditto on the lighters, 14 days full rations on the transports. The cooking apparatus of the transports was supplemented by the field kitchens of the troops on board. Live cattle were carried, of which it was necessary to slaughter 80 per day to provide the ration of 200 grammes per day, the animals of the country being very small and in bad condition.

Fuel Wood for two days was to be landed with the troops, and provision was made for supplementing the scanty shore supply for a period of up to 3 months after landing.

Forage.—Five kilogrammes of barley and 3 of hay were to be landed for not exceeding 400 animals per brigade at the original landing, comprising only the horses of commanders, staffs, and despatch riders ; and the mules of batteries, ambulances and mobile parks. The balance of the total 1,100 animals per brigade being landed later. Three months' forage was provided.

Camping Material.—Nine thousand bivouac shelters, 600 bell tents, 40 marquees, 2 portable electric light sets for hospitals.

Medical Stores.—Units carried their complete medical and surgical equipment, which was to be replenished from a medical park with each brigade.

Two surgical sections, with a hospital for 300 beds, accompanied each brigade.

Two launches, each towing two lighters, conveyed casualties from shore to each brigade hospital ship for evacuation to the base hospitals of Ceuta, Melilla, or Malaga.

Signals.—Divisional headquarters were equipped with a pack W/T. set, and with pack visual and telegraphic and telephonic apparatus.

Each brigade had 3 small W/T. sets, 7 V/T. stations, and 30 kilometres of cable with 20 L/T. or telephone stations.

Maps.—An aerial survey had been completed during the previous month and was issued in the form of squared maps (no details given).

Execution.

The troops embarked on September 5th at Melilla and Ceuta, immediately the loading of the stores and material was completed,

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and put to sea on the 6th, escorted respectively by the French and Spanish Naval Squadrons.

Feint bombardments of Wad-Lau and Sidi-Dris (35 kilometres to the east of Axdir) were carried out on the evening of the 6th. On September 7th, while the Spanish Squadron was bombarding the shores of Bocoya, the French Squadron again bombarded Sidi-Dris, making a feint at landing from boats and lighters covered by a smoke screen.

During the night of the 7th-8th the transports and lighters remained some six miles off the shore, and the morning of the 8th found the whole convoy drifted by the current some 30 miles to the westward of Cebadilla, and so scattered that the bulk of it was not re-united until the 9th, some vessels not having rejoined even by then.

Meanwhile, events further to the west (Kudia-Tahar) had made it necessary to be prepared to detach a portion of General Fernandez Perez's (Melilla) brigade in that direction. The projected landing at Cala del Quemado was, therefore, abandoned, and all landings ordered to be effected on the N.W. shore of the Bocoya peninsula, the beach at El Fraille being chosen for General Perez's brigade.

The weather was fine, but the beaches were found cramped, with a rocky bottom, and very exposed to the swell. Enemy artillery fire compelled the transports to keep several miles out to sea. The slow speed of the "K" lighters delayed matters considerably until orders were given for them to be taken in tow by gunboats to within 1,000 metres of the coast, the G.O.C. himself leading them in a torpedo boat. The actual landing was almost unopposed (thanks to the success of the feints) except by long range artillery fire, and the first troops got ashore about noon on September 8th, after having had to wade more than waist deep. Pushing on in the face of slight opposition they occupied the high ground of Morro Nuevo (where they captured artillery), on the left, and Ixdain on the right, reaching the first under features of Malmusi. They were subsequently withdrawn from these advanced positions as positions in rear were consolidated.

Fine weather prevailed on the 8th, 9th and 10th, and enabled most of Saros brigade to disembark successfully with water and stores at Cebadilla, but things did not go so smoothly at El Fraille beach. Here the combined effect of artillery fire, which caused 200 casualties, shortage of launches, and faulty co-operation between navy and army (which the author states is always to be expected in his country) seriously delayed the disembarkation of Perez's brigade. Added to these, a "Levanter" gale sprung up on the 11th, sinking several lighters and suspending landing operations. The most serious immediate result was an acute shortage of water on shore, which necessitated the reduction of the ration to two litres

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per day, and precluded the possibility of landing any of the horses or mules. Only two days' rations had been landed.

The brigade at Fraille had to be subsisted temporarily on the brigade at Cebadilla, immobilizing both, congesting the approaches, attracting enemy artillery fire.

The enemy seized the opportunity to attack strongly on the Spanish left on the 11th, 12th, 13th and 19th, causing heavy casualties.

It was not until the 22nd that it was possible to land the transport horses and mules. By this date over 1,000 casualties had been incurred.

A general advance in five columns had been planned for the 23rd, but was delayed by the failure of the air forces to co-operate as ordered (no reasons given). Its inception at a late hour on that date was only due to the refusal of one of the column commanders (Colonel Goded) to obey the divisional order to wait for the aeroplanes. The objectives were gained at the cost of 650 casualties, and it became possible to use the beach at Cala del Quemado, as originally planned, in substitution for that of El Fraille.

Water fit for horses and mules was discovered, but the drinking water situation became critical during another gale from the 25th to the 27th, when the water barges were unusable and almost wrecked. The ration on the latter day was reduced to ½ litre, but the passing of the gale enabled the ration to be again raised to two litres, at which figure it was subsequently maintained. The distribution of water presented much difficulty, involving free fights at times.

The remainder of the operation proceeded slowly but with complete success, and the final objective at Axdir was attained on the 2nd October.

Summary.

The author considers the plan to have been extremely well conceived, and the secrecy and methods of deception which were practised to have achieved complete success. He states that the preparations showed a great advance on the previously proverbial Spanish lack of foresight.

In addition to the material difficulties (which were great) the Chief Command had to deal with the lowered morale produced by previous lack of success in the Morocco Wars and by the example of the Allies' failure at Gallipoli.

The exemplary courage and initiative which all ranks displayed paid a high tribute to the manner in which the Commander-in-Chief succeeded in overcoming these difficulties.

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TRANSLATOR'S COMMENTS.

(1). The hybrid organization of the two "Brigades," and the grouping of more than twelve major units under one Brigade Staff, appears to be open to criticism: the more so as the brigades appear to have been again reorganized into five "Columns" directly they were ashore and the advance commenced.

(2). The theoretical advantages of having Navy, Army, and Air Force directly under one commander do not seem to have materialized in this case, as the convoys failed to arrive within 30 miles of their destination at the appointed time, the capabilities and limitations of the lighters do not seem to have been realized, and the Air Force entirely failed to put in an appearance when required.

(3). The arrangements for landing and distributing water were evidently inadequate, and water discipline lacking.

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WAZIRI. WAYS.

By BRIGR.-GENL. H. H. AUSTIN, C.B., C.M.G., D.S.O.

The Waziris probably require little introduction to British readers. When the tremendous clash of arms that had resounded throughout the civilized world for more than four years began to die down in Europe, Palestine, Mesopotamia and East Africa, this devastating war that was to end war was certainly not regarded in that light by our wild neighbours dwelling along the North-West Frontier of India. During the titanic struggle the Waziris had not been drawn into the ambit of the conflagration. Indeed, their hands had then been freer than usual to embark on a policy of pin-pricks, so dear to the Waziri soul, by raiding into British territory and indulging in other acts of defiance towards the long-suffering *Sirkar*, whose attention was already more than fully occupied by the enormity of the demands made on its resources. Thus, for a time, Waziri misdeeds did not meet with the prompt and condign punishment they so richly merited, and it was left to a later period, when the Government was less embarrassed by the events of the Great War, and another war with Afghanistan on the top of it, to resume the old, old story of marshalling forces to excise the Waziri thorn in the flesh.

And so for some years past the Indian Government has once again been engaged in the subjugation of these recalcitrant mountaineers, elusive will-o'-the-wisps who inhabit a region of great physical difficulties abounding in rugged ridges and deep rocky gorges, radiating from lofty ranges whose summits attain an altitude of 11,000 feet above sea level. It is probably due in some measure to the barren, inhospitable character of the country, and its lack of resources, that the Waziri in general, and the Mahsud clan in particular, look elsewhere to supplement their means of existence. Naturally brave and warlike, they have no scruples in depriving their less warlike neighbours of what they do not themselves possess, by fierce forays carried out with rapidity and daring. Hence one may suitably apply the term Ishmaelite to this race, for their hands are certainly against every man's and most men's against theirs. Nevertheless, the Waziri does not seem weighed down by this distinction ; and doubtless still inwardly believes, what for many generations he openly boasted, that he alone of all the Afghan clans remains free.

Be that as it may, the whole tribe are thieves, and are proud of their prowess in the subtle art of plunder. Unless paid blackmail, they light-heartedly raid their neighbours and carry off cattle, camels, rifles and ought else they can lay their hands upon, for all is grist to

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their mill. Yet hospitality is regarded as a prime virtue among them; and each village has a place set apart for guests, who are welcomed at dawn and at sundown, when prayers are being said, after which they are provided with food. The cost of hospitality is borne by the whole village; and the Waziris claim they have no poor, because whenever a family is brought low, the rest of the clan subscribe to re-establish it. Thus there is little incentive for the Waziri to quit his wild home to seek his fortune elsewhere, so he remains in the hills all the year round, which is probably one of the reasons why he does not enlist readily in the ranks of the Indian Army.

Though the Waziris profess to recognize no other law or will but their own, they do observe some form of rough justice in their intercourse with each other, by inflicting money fines for murder and other assaults within the community. Whether the scale has been materially affected by the present high cost of living in western lands, I do not presume to say; but formerly the pecuniary compensation for the murder of a fellow-tribesman was Rs. 1,300, half of which had to be paid in hard cash, and the other half in produce and commodities, including two girls, valued at Rs. 100 each. The fine for the murder of a woman was half that for a man. Other gradations followed; the loss of a limb or eye by a sword cut being valued at Rs. 500; that of the nose Rs. 250, and of an ear Rs. 100. Gun-shot and dagger wounds were less highly fined, and ranged from Rs. 100 to Rs. 50, according to whether death was to be apprehended as a result of the wound or not. Adultery was punished by the man having a foot cut off with a blunt knife or saw; and victims to this barbarous method of mutilation, furnished with a wooden leg, are to be seen at times stumping the steep hill-sides of Waziristan. Drastic measures are probably necessary to maintain the sanctity of family life, for marriage is chiefly a matter of barter, the cost of a bride being from Rs. 60 to Rs. 150.

Plundering, as already stated, is one of the main professions of this turbulent tribe; not from each other, be it noted, for some honour still obtains among these notorious thieves. But woe betide any wayfarer who happens to fall into the clutches of these marauders, if of an alien tribe. Apart from the plains of the Derajat, perhaps the most fruitful raiding grounds of the Waziris lie beyond their southern borders, along the gorges of the Gomal river and lower stretches of the Zhob. This is wild country, indeed, where gangs of *budmashes* can find ready means of concealment amid the broken hills and rocky recesses of sombre vales. From these convenient lairs they can issue forth on unsuspecting travellers in the twinkling of an eye, and retire again to such haunts with their ill-gotten booty long ere their sudden swoop is reported to posts designed to protect the peaceful pedestrian, and trader bearing goods along these infested highways. Thus there

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is little love lost between the Waziris and those whom they delight to victimize, so long as the chances of success are entirely in their favour.

This Ishmaelite outlook of the Waziri has, not unnaturally, caused him to be regarded as an enemy of mankind by other tribes dwelling within raiding radius ; and by those accustomed to traverse certain routes, leading to and from India, located within striking distance of Waziri territory. Of such routes the gorge of the Gomal, above its junction with the Zhob, is that perhaps most frequented by caravans proceeding from Afghanistan to the plains of India; and this was for generations a happy hunting resort of Waziri bands. Between the Powindahs—migratory Ghilzai warrior traders whose homes are about Ghazni—and the Waziris, it was a matter of war to the knife; for the Waziris never lost an opportunity of raiding Powindah caravans when these twice annually passed along the Gomal, going to and returning from India. How great were the possibilities of loot during these migrations will be realized when it is stated that about 50,000 of these nomads, men, women and children, accompanied by thousands of camels, and immense flocks of goats and sheep, entered the Dera Ismail Khan district every year by the Gomal route from the middle of October to the middle of December, and returned to Ghazni between the 20th March and 10th May. It is small wonder, then, that these Powindahs marched through the Gomal in regular armies, and were well organized to meet the attacks of Waziris, who were always on the look-out to cut off stragglers, and to fire on the Powindahs from the heights dominating the tracks followed. Hence, a captured Waziri experienced short shrift at the hands of the Powindahs. He could expect no mercy, so usually resigned himself to his fate —a simple one, for he invariably had his throat cut as though he were a sheep, and was buried on the spot without any further to-do.

The Powindah method of dealing with the hated Waziri was gentlemanly in comparison with the punishment meted out to him when caught by Nasirs. In each case death was all he could hope for; but he now had the questionable pleasure of observing, as a preliminary, a metal plate being heated in a fire until it became nearly red hot, the purport of which he quite well understood. The executioner would then step forward, and with one deft stroke of his keen tulwar completely behead his victim. Before the blood had time to gush forth, the hot plate would be clapped on to the trunk by assistants; whereupon the Waziri's headless body would perform a series of leaps and bounds to beat of drum and the undiluted glee of Nasirs gathered round to watch its antics. Thus was the Waziri loved by those of his co-religionists he was ever ready to murder and spoliate.

Near by, but mostly beyond our border in this area, a large tract of country is occupied by the powerful and warlike Sulaiman Khel tribe. A considerable number of them also migrate to India in the cold weather, and there they behave well enough, though they have

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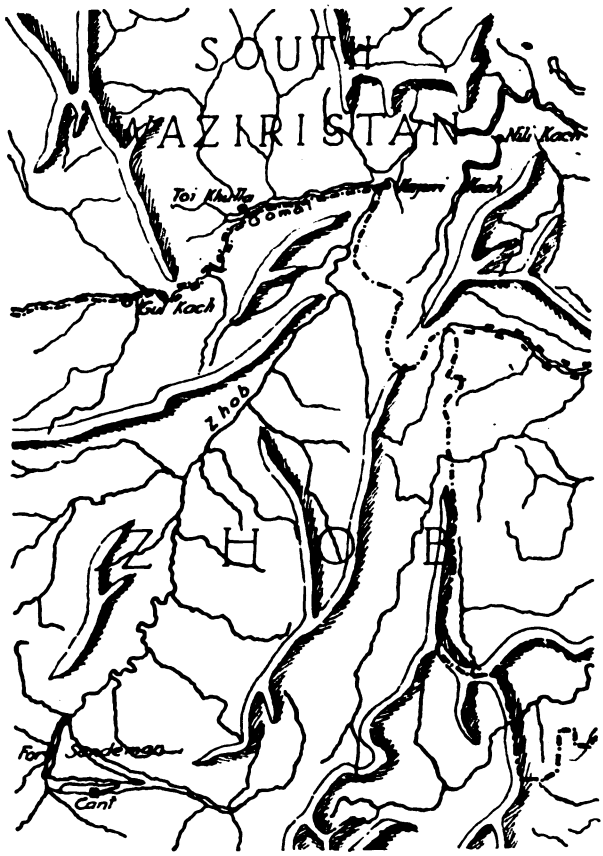
the reputation of being very rough customers outside British territory. Between them and the Waziris, likewise, there is perpetual strife, and they seldom lose the chance of waylaying each other when the odds are about four to one in favour of the assailants. The origin of this feud is connected, by report, with the possession of the Wana plains, whereon good grazing grounds, always a contentious subject, are to be found at certain seasons of the year. In any case, Waziris and Sulaiman Khels loathe and have a wholesome dread of each other; and will never willingly travel in twos and threes in the vicinity of the other's habitat, particularly along the Gomal.

Now, it had long been known by the authorities in India that the Gomal was a great highway of Afghan traders (Powindahs) between Central Asia and India. Yet, up to 1889 our knowledge of this important line of communication was extremely scanty, resting almost entirely on native information. In the summer of that year Sir Robert Sandeman had proceeded on a tour down the Zhob from



Loralai, near Quetta, and reached its junction with the Gomal at Kajuri Kach. Thence he continued over the Gwaleri Kotal (pass),

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avoiding impassable gorges in the Gomal—the name given to the now combined streams—and descended to the lower stretches of the river about Nilai Kach, from which point he followed it to the plains of India.

But the upper course of the Gomal, flowing generally E.N.E. from the Zermelan plain to join the Zhob, was still but vaguely known. Indeed, from where the river entered the gorges that commence at the eastern extermity of that plain, and continue throughout the intervening twenty-five miles to Kajuri Kach, it remained a *terra incognita* until surveyed by a section of the Zhob Valley Railway Survey expedition between December, 1890, and February, 1891.

As we were the first Europeans to visit and spend some weeks in these wild gorges, to which Waziri territory extended, it was hardly to be expected that we would escape the attention of these profesional thieves during our sojourn along their border. In anticipation of the possibility that the Waziris might prove troublesome whilst survey work was in progress, a covering force of the 3rd Baluchis, and a squadron of the 12th Bengal Cavalry, occupied a standing camp at Gul Kach, out on the Zermelan plain, a short distance up-stream of the western entrance to the Gomal gorge.

The survey section numbered five British officers, some forty armed Pathan *khalassies* to assist in outdoor work, and an escort of fifty men of the 3rd Baluchis under an Indian officer. Our transport consisted almost entirely of hired camels with their owner attendants. The covering force and the survey section had marched together to Gul Kach from Apozai (now Fort Sandeman) through some fifty miles of very broken hilly country, the abode of many bad characters, before we reached the bank of the Gomal on the 14th December, 1890. A certain amount of preliminary survey work had to be done in the vicinity prior to undertaking the gorge portion of the Gomal; and it was then decided that we should proceed down-stream to Kajuri Kach, and work upwards from the Gomal-Zhob junction to Gul Kach, thus carrying on the survey being done by another party below the junction.

To march down the Gomal gorge with camel transport from Gul Kach was impracticable, owing to its precipitous character in the first six or seven miles; so Lieut. (now Col. Sir Henry) MacMahon, the Political Officer with the force, arranged that we should follow the Powindah track on the left bank of the Gomal. This led over the Kandori Pass, avoiding the upper gorges and striking the river again at Toi Khula, where the Toi stream, draining the Wana plains to the north, joined the Gomal about midway to Kajuri Kach. The country on the left bank hereabouts was temporarily treated as though under the sway of the Amir of Afghanistan, pending the final agreement as to the boundary—arrived at some years later; for which reason MacMahon enlisted the services of twelve Sulaiman Khels to

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accompany us, as sureties for our safety whilst traversing this corner of then foreign territory.

These twelve gentlemen were fine specimens of humanity, their leader standing not less than 6′ 3″ in height, and broad in proportion. Although mostly of villainous mien, they inspired a certain amount of confidence in their ability to protect our sanctity, by reason of their warlike appearance, for they were little short of perambulating arsenals. Each carried a *jezail*, the old flint-lock musket, and a goodly supply of powder in flasks, and spherical bullets for the medieval weapon. A curved tulwar, flint-lock pistol, and an evil-looking dagger, all thrust into his waist-band, reinforced his armament. So long as they remained on our side of the river, and under the sheltering care of the battalion and cavalry, never was seen such a stout set of fellows. But, alas, when the small survey party left the covering force, waded across the Gomal, threaded its way through a mass of clay cliffs and mounds, the reputed site of the ruins of Sodom, and turned away up the broken slopes leading to the Kandori Kotal, our sureties began to lose a good deal of their pristine swagger. Further, their superb chief contrived to give us the slip, whilst we clambered with our camels towards the summit of the Kandori; because, we subsequently learnt, his brother had been shot dead thereabouts by the Waziris only a short time before. He deemed it prudent, therefore, to return to MacMahon at Gul Kach, leaving his colleagues to escort us to our destination. Presumably he felt he would be unable to curb his desire for revenge should we, unhappily, stumble across a few Waziris during our trek ; and thus create complications.

The Kandori clearly boasted an evil reputation, for stone cairn memorials to those who had met with violent deaths were seen at intervals. Just irregular heaps of stones they were, at the side of the track, and on these the interested traveller tossed his quota as he passed, in accordance with his sympathies. Thus was homage paid to any particular cairn that appealed to him as indicating the spot where a Waziri, or one of the many enemies of that tribe, had bitten the dust. Our good Sulaimans, however, successfully steered our course for some sixteen miles through very intricate country, and landed us on the bank of the Gomal, which we again forded and pitched camp on a small plot of stony ground overlooking the river. And here we spent a most miserable Christmas next day, as it blew great guns straight off the snows, and rained heavily.

Having got us so far, the Sulaimans began to work themselves up to a very nervous state. They clamoured to be permitted to return to Gul Kach, averring that if they proceeded farther to Kajuri Kach they would inevitably be cut to pieces by the Waziris when they set out thence for their homes. In short, they endeavoured to convince us that we would be guilty of little less than murder did we persist

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in taking them on. But the arrangement agreed upon at Gul Kach, and for which these men had been paid in advance, was that they should accompany us as far as Kajuri Kach—now only twelve miles distant. So they were held to their bargain, and marched with us down the gorge—here practicable for camels by frequently crossing from one bank to the other—to the Zhob-Gomal Junction.

There it certainly was not encouraging for them to learn that a band of forty or fifty Waziris were on the rampage in the neighbourhood, and had recently been giving trouble to the other railway survey party working in the Gomal gorges below the junction of the rivers. These rogues had, a day or two before, waylaid the Hindu *syce* of one of the officers, eased him of such cash as he had about him, stripped him naked save for a thin cotton shirt, and sent him back to camp in this *negligé* attire. It was the depth of winter and bitterly cold, so the *syce* failed to appreciate the untimely jest quite to the same extent as the witty Waziris. A few nights later the rascals went one better, and succeeded in extracting a Snider carbine from under the head of one of the Pathan *khalassies*, who was sleeping on it by way of a pillow in a tent in the same camp. The slumberer was not even awakened, nor the theft discovered until the morning, which suggests consummate skill on the part of the thief.

And this state of things was going on within a few miles of a Waziri Levy post, which had been established on the right bank of the Zhob, overlooking its junction with the Gomal, for the specific purpose of protecting travellers from the depredations of other Wazari thieves. I say " other " advisedly, for the subsidised Waziri occupants of the post, numbering about sixty in all, were not above taking part in plundering exploits themselves when favourable opportunity offered, as I will presently show.

Our camp at Kajuri Kach was pitched on the right bank of the Gomal, in the angle formed by the junction of the two rivers, the stony bed of the Zhob being 500 to 600 yards wide here, and that of the Gomal from 300 to 400. Looking straight across the former, one saw the Levy post perched on a small plateau well above the highest known flood level of the waters' meet—a very formidable affair a short way down the gorge below the junction. The post consisted of a small rectangular enclosure, surrounded by high loop-holed walls of mud, with a tower at one corner and a bastion at the diagonally opposite one. Quarters were provided for the Waziri levies round the base of the four walls, the roofs forming the banquettes for manning the loopholes above. On the ground floor of the tower was a small sitting room and a tiny bathroom, for the use of British inspecting officers, with a sleeping apartment on the storey above. These upper and lower rooms were supplied with windows in the outside walls. protected by bullet-proof shutters of wood and iron.

When sent back with a few men on one occasion from our camp at

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Toi Khula, to complete some work between that place and Kajuri Kach, I had the privilege of spending one night with Mr. Donald, a Political Officer, in this cramped post. This had for the nonce to furnish shelter for something like 120 men—including the Waziri garrison—and a number of horses and mules belonging to Donald's and my parties. Now Donald had spent his life, almost from boyhood, on this frontier, could speak Pushtu like a native, and what he didn't know about the tribes on our border wasn't worth knowing. Nevertheless, little did he trust our presence, and that of the Waziri levies, as likely to render the post sacrosanct from outside attention by night. So the lower room bullet-proof shutter was closed whilst we partook of our evening meal and occupied that chamber before retiring to rest. And it was not until we were about to get into bed in the upper room, and had "doused the glim," that its bullet-proof shutters were re-opened to admit fresh air during the night.

In justice to the Waziri levies, however, it is only right to say that during the week our survey section was camped at Kajuri Kach we were not molested by thieves. Our work then required camp to be moved some six miles up the Gomal to Shaidan, about midway to Toi Khula. Here the ground consisted of a series of small flat terraces, covered with black boulders and stones; and camp was pitched on one such terrace facing the river, with another terrace rising in rear and more or less defilading the camp from the hills and cliffs behind. Whilst in these regions all our camps were laid out with great precision, almost to the fraction of a foot. They were rectangular in shape, the long sides approximately fifty yards in length, and the shorter thirty. Tent ropes overlapped round the entire perimeter save for the 10-foot roadway running through from one long face to the other; and just outside their entrances two sepoys' tents were pitched. Camels, mules and ponies were tethered close alongside one face of the camp under the eyes of the guard-tent; and sentries posted at short intervals around the whole circumference.

Taking the terrain to be traversed into consideration, it would seem no easy matter, then, for the most skilful of thieves to penetrate the cordon of sentries, and worm his way into the camp itself through all those tent ropes, particularly as we officers had about half a dozen excellent watch-dogs sharing our tents. Yet, shortly before the moon rose on the 5th January, a Waziri managed to get right into the camp, and absconded with the entire change of kit belonging to one of the *khalassies*. He was certainly seen disappearing with his loot, and was fired on by a Baluch sentry; but his approach to the camp was never spotted, and he got clean away.

This exploit was apparently intended merely as a feeler; for a couple of nights later, when the sky was much overcast, a thunderstorm threatening, and rain falling at intervals, the camp was aroused at about 2 a.m. by the report of a rifle, followed by several others.

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We hastily donned our *poshteens*, buckled on belts with revolvers, snatched up our rifles and dived out of our tents, imagining a night attack at least was taking place. The Pathan *khalassies* were all at their alarm posts in no time, manning the gaps between the tents; so seeing all in readiness here, we moved over to the guard-tent in rear of camp, whence the sepoys were still firing. There we learnt that some thieves had managed to creep between the sentries and enter the camp, making a bolt for it under fire when detected. A few apparently had not fled very far, and were ensconced behind several big rocks a short distance in front of the guard-tent; for, out of the darkness, stones were being pitched towards the tent and falling around us. It was senseless waste of ammunition to fire into the inky blackness, where one could not see ten yards beyond one; more particularly so since the thieves were absolutely safe behind the rocks. Thus, a British officer sallied forth with ten sepoys to rout the rogues out from their lair. Not a sign of them did he see, however; but during his twenty minutes' patrol he stumbled upon a large packing case, containing two dozen boxes of 100 cheroots each.

The thieves had abstracted this from the Swiss Cottage mess-tent, which occupied one corner of the perimeter, in continuation of the officers' line of tents. In spite of sentries and alert dogs close by, the expert rascals had boldly removed the case between the line of sentries and out into the void, though it must have required a couple of men to carry it owing to its bulk; and all this was done without making a sound or disturbing a soul in camp! Seemingly they had only abandoned their booty when fire was opened upon those of their confederates detected within the camp.

To appreciate fully the skill of the feat, it might be added that were you and I to attempt to pick our way across that stony terrace in the broad light of day, with no encumbrance of any sort and grass sandals on our feet, we would surely raise a rare commotion. This would be magnified to so great an uproar in the silence of the night as could not fail to awaken the most somnolent of sentries. There were ten watchful guardians distributed round the whole camp—a perimeter of about 300 yards, including the animal lines. The thieves must have passed within ten or fifteen yards of sentries, therefore, both coming and going.

One was faced by somewhat novel conditions in dealing with these Waziri thieves; and the sentries did not at first realize that the pitching of stones towards the camp from the darkness without formed an integral part of the plan of campaign of these rogues. Having worked their way to within striking distance of the camp, so to speak, even the cat-eyed Waziris were unable to locate the position of the sentries, for these were generally concealed in shallow pits round the perimeter, and did not tramp backwards and forwards along regular beats. Thus it was essential to mark down the sentry

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posts before further action could be safely embarked upon, and so the stone-throwing ruse was employed.

A sentry first subjected to the insult of having stones pitched in close juxtaposition to his place of concealment would probably imagine he had been spotted, and was being made a foolish target of; indignantly, or nervously, as the case might be, he would reply by loosing off his rifle in the direction whence he thought the stones were being thrown. This was precisely what the Waziri wanted. The bullet would pass harmlessly over his head, and he had got that sentry's position marked down to a foot. Now for the next; and so on.

So far so good; but the Waziri had yet to traverse the intervening stony space between himself and the line of sentries, in order to enter the precincts of the camp—unheard and unobserved. How did he do it? It is obvious his movements must now be very deliberate; but time was of little concern to these patient and persistent thieves, so long as they ultimately achieved success after the sentry had been lulled into a sense of security by stones ceasing to drop in his vicinity. Then, in a low crouching attitude, the serpent would crawl from his cover, and softly clear away with his hands the stones from the spot to which the next foot was to be advanced. Thus, step by step, with infinite caution and quite noiselessly, would he creep closer and closer, and finally pass between the line of sentries in the pitchy darkness of the night selected for his operations. The cold, calm courage of the rogue, and his inexhaustible patience, would be worthy of much admiration were these attributes directed into less reprehensible channels. But Waziri cunning, unfortunately, occasioned us much food for reflection during the period we were subjected to frequent night alarms by reason of it.

It did not take long, however, to instil into the minds of the sentries that, by replying to the stones falling around them, they were but giving their positions away; so that little weakness of theirs was quickly quashed. We officers, too, often sat up for hours hidden in pits, hoping for a chance to take toll of these nocturnal prowlers; but they were wary birds, and evidently endowed with the gift of acute scent, as well as of uncanny sight in the dark, for not one of us ever obtained a glimpse of, or shot at, these pests. Yet, shortly after abandoning the vigil, in order to snatch a few hours' sleep before the labours of another day, we would probably hear the "bang, bang" of rifles, and be out of our beds again in a trice to investigate the cause.

The causes were sometimes comic, but generally the reverse. From considerations of space I can give but one example of each from various experiences at Toi Khula camp, to which we moved from Shaidan on the 9th. January. Our camp was pitched on the same site as that of Christmas Day, on a flat plot of high ground on the right bank, and immediately overlooking the river, down to which the

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drop there was precipitous; whilst in the stony bed was a considerable patch of tall reeds through which the icy stream flowed. Directly opposite the camp, on the left bank, a huge, conglomerate cliff rose sheer out of the river bed to a height of 200 or 300 feet, and indicated the place just below which the Toi entered the Gomal.

The first night or two after settling down into a new camp we were usually left alone; or so it seemed, though the Waziris probably employed the time in getting a hang of our fresh arrangements before embarking on operations. Their initial exploit at Toi Khula was announced by terror-stricken shouts in the small hours of the morning by one of the *khalassies*. These were sufficiently blood-curdling to convince one that the wretched man was having his throat cut; and promptly caused us to hasten to his aid, and that of the other occupants of his tent. There it came out that the man had been a prey to bad nightmare, and awoke with a jerk to feel someone trying to pull the socks off his feet! This proved too much for him in his disorganised condition, and he let out the succession of yells which had thrilled light sleepers throughout the camp. The Waziri was seen by no one, so must have slipped away in the darkness when the *khalassi* gave tongue. He departed without the socks, but with a couple of useful cooking-pots to compensate him for having to continue his tramps bare-footed.

Another week of almost nightly alarums and excursions followed; and then we had the mortification of losing the only rifle captured by Waziris throughout these series of séances. It was taken from one of our Baluch regulars, too, which made the circumstances all the more regrettable, being entirely due to the man's own stupidity. It had been a clear, frosty moonlight night, a priceless boon to the wanderer in wild regions, and had passed peacefully. But just after the moon set the sentry sought to warm himself at a fire some ten yards distant from his post, and which, incidentally, had no right to be burning. Instead of taking his rifle along with him, however, the oaf laid it against a rock and sauntered off to the fire. In the twinkling of an eye two Waziris sprang up from nowhere; and whilst one discharged his pistol at the now unarmed sentry the other seized the Martini, and both were gone again like a flash. Before any of the other sentries could get a shot at them, they disappeared over the low rocky cliff into the bed of the river, and vanished into the reeds through which they gained the opposite bank unseen. A picquet was at once sent in pursuit, but small chance had it of overtaking the rascals, to whom every recess along the course of the Toi was as familiar by night as by day. So that Martini was struck off the strength, and the sentry conveyed under arrest to regimental headquarters at Gul Kach, to be tried by court-martial for gross carelessness.

After a time we grew somewhat weary of the ceaseless attentions

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of the Waziris by night, though we seldom saw any sign of them by day whilst engaged on survey work in the gorge. Ultimately, we determined to circumvent the ruffians by constructing low stone walls round the entire camp perimeter. These light structures were too high to step over, and so flimsily erected that any portion interfered with came down with such a clatter as could not fail to give the alarm at once. This simple device was quickly run up, thanks to the fine crop of stones always to hand, and proved most efficacious. Henceforth, during the next month in the Gomal, we usually enjoyed undisturbed nights in bed; and the Waziri thief had to admit defeat.

Whilst at Toi Khula, we were sufficiently distant from Kajuri Kach to afford no semblance of protection to travellers supposed to derive that boon from the presence of the Levy post at the junction of Zhob and Gomal; and it has been shown that between Waziris and Sulaiman Khels much ill-feeling existed, to put it mildly. Thus it was not altogether surprising to be appealed to one day, when at work near Toi Khula, by two bedraggled, woe-begone Sulaimans who had hurried up-stream to pour forth their tribulations in our ears. Their story was to the effect that a party of seven of them, with twenty-one camels, were returning from India to their homes carrying 300 rupees in cash, and valuable goods loaded on their animals. Relying on the protection of the Government post, they pitched their camp for the night on the site we had occupied a short while before, and retired to rest after their evening meal.

They were roused from their slumbers some hours later by finding themselves surrounded and set upon by a band of about forty Waziris. Before they had time to defend themselves, two of their number were killed, two others wounded, and their entire possessions looted by the gang, who promptly decamped with their booty. The Sulaimans were prepared to swear that the Waziri levies of the post were concerned in the attack, for they recognised dogs that belonged to men in the post. One could readily believe it; but it was difficult to see what was to be done in the matter beyond furnishing the disconsolate victims of the outrage with a letter to the Political Officer of these parts, in the hope that he might be able to redress their wrongs.

The Waziris had certainly got the better of the Sulaimans by treachery this time; and one could but trust that Sulaimans elsewhere along this turbulent border had simultaneously scored off the Waziris. The ebb and flow of opportunity probably worked out pretty well "all square" between these inveterate enemies, year in and year out; and as we were but peaceful toilers in this land of strife and unrest, repression of Waziri ways was entirely outside our province.

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BATTLE HONOURS OF ROYAL ENGINEER UNITS (continued).

N.B.—"LYS" COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN ANY OF THE BATTLES FROM ESTAIRES TO SCHERPENBERG.

ESTAIRES. 9TH-11TH APRIL, 1918.

Unit.	Formation.	Remarks.	
FIRST ARMY.			
ARMY TROOPS.			
"D" Special (Cylinder) Co.	XI Corps	E.	
"F" ,,	XV ,,	,,	
No. 1 Special (Mortar) Co.	XI ,,	,,	
No. 3 ,,	XV ,,	,,	
134th Army Troops Co.	IX ,,	,,	Attached 25th Div.
145th ,,	XV ,,	,,	
552nd ,,	XI ,,	,,	
556th ,,	XV ,,	,,	
1st Aust. ,,	IX ,,	D.	Attached 25th Div.
251st Tunnelling Co.	XI ,,	E.	
XI CORPS.			
56th Field Co.	3rd Div.	N.E.	
438th ,,	,,	D.	
529th ,,	,,	N.E.	
400th ,,	51st Div.	E.	
401st ,,	,,	,,	
404th ,,	,,	,,	
419th ,,	55th Div.	,,	
422nd ,,	,,	,,	
423rd ,,	,,	,,	
476th ,,	61st Div.	,,	
478th ,,	,,	,,	
479th ,,	,,	N.E.	
23rd ,,	1st Div.	,,	
26th ,,	,,	,,	
409th ,,	,,	,,	
XV CORPS.			
455th Field Co.	29th Div.	E.	
497th ,,	,,	,,	
510th ,,	,,	,,	
210th ,,	31st Div.	N.E.	
211th ,,	,,	E.	
223rd ,,	,,	N.E.	
207th ,,	34th Div.	E.	
208th ,,	,,	,,	
209th ,,	,,	,,	
224th ,,	40th Div.	,,	
229th ,,	,,	,,	
231st ,,	,,	,,	
7th ,,	50th Div.	,,	
446th ,,	,,	,,	
447th ,,	,,	,,	
105th ,,	25th Div.	N.E.	
106th ,,	,,	,,	
130th ,,	,,	,,	
57th ,,	49th Div.	E.	
456th ,,	,,	N.E.	
458th ,,	,,	,,	

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SIGNALS.

ESTAIRES. 9TH-11TH APRIL, 1918.

Unit.	Formation.	Remarks.
First Army Signal Co.		N.E.
L. Corps Signal Co.	XI Corps	E.
3rd Divl. Signal Co.	,,	,,
51st ,,	,,	,,
55th ,,	,,	,,
61st ,,	,,	D.
1st ,,	,,	N.E.
P. Corps Signal Co.	XV Corps	D.
29th Divl. Signal Co.	,,	E.
31st ,,	,,	D.
34th ,,	,,	E.
40th ,,	,,	,,
50th ,,	,,	,,
25th ,,	,,	N.E.

MESSINES, 1918. 10TH-11TH APRIL, 1918.

Unit.	Formation.	Remarks.
SECOND ARMY.		
ARMY TROOPS.		
No. 2 Special (Mortar) Co.	IX Corps	E.
134th Army Troops Co.	,,	,, Attached 25th Div.
167th ,,	,,	,,
1st Aust. ,,	,,	,, Attached 25th Div.
184th Tunnelling Co.	,,	N.E.
No. 351 E. & M. Co.	,,	D.
No. 8 Foreway Co.	,,	,, No diary.
IX CORPS.		
63rd Field Co.	9th Div.	E.
64th ,,	,,	,,
90th ,,	,,	,,
81st ,,	19th Div.	,,
82nd ,,	,,	,,
94th ,,	,,	,,
105th ,,	25th Div.	,,
106th ,,	,,	,,
130th ,,	,,	,,
97th ,,	21st Div.	N.E.
98th ,,	,,	,,
126th ,,	,,	,,
11th ,,	33rd Div.	,,
212th ,,	,,	E.
222nd ,,	,,	N.E.
57th ,,	49th Div.	,,
456th ,,	,,	E.
458th ,,	,,	,,
XV CORPS		
455th Field Co.	29th Div.	N.E.
497th ,,	,,	D.
510th ,,	,,	N.E.
207th ,,	34th Div.	N.E.
208th ,,	,,	,,
209th ,,	,,	D.

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SIGNALS.

MESSINES, 1918. 10TH-11TH APRIL, 1918.

Unit.	Formation.		Remarks.
Second Army Signal Co.		N.E.	
E. Corps Signal Co.	IX Corps	D.	
9th Divl. Sig. Co.	,,	E.	
19th ,,	,,	,,	
25th ,,	,,	,,	
21st ,,	,,	N.E.	
33rd ,,	,,	,,	
49th ,,	,,	D.	

HAZEBROUCK. 12TH-15TH MARCH, 1918.

Unit.	Formation.		Remarks.
FIRST ARMY.			
ARMY TROOPS.			
"D" Special (Cylinder) Co.	XI Corps	E.	Fleming's Force 51st Div.
"F" ,,	XV & Can. Corps	N.E.	
No. 1 Special (Mortar) Co.	XI ,,	E.	Attached 51st Div.
No. 3 ,,	XV ,,	N.E.	Within area but not employed.
134th Army Troops Co.	IX Corps	N.E.	
145th ,,	XV ,,	D.	
167th ,,	IX ,,	N.E.	
230th ,,	XI ,,	E.	
235th ,,	VIII ,,	N.E.	
552nd ,,	XI ,,	E.	
556th ,,	XV ,,	,,	
557th ,,	VIII ,,	N.E.	
1st Aust. Army Troops Co.	IX ,,	,,	
170th Tunnelling Co.		,,	
171st ,,	IX Corps	,,	
184th ,,	IX ,,	E.	
251st ,,	XI ,,	N.E.	
255th ,,	IX ,,	D.	No diary.
3rd Can. ,,	IX ,,	E.	
I CORPS.			
56th Field Co.	3rd Div.	E.	
438th ,,	,,	,,	
529th ,,	,,	,,	
9th ,,	4th Div.	,,	
406th ,,	,,	,,	
526th ,,	,,	,,	
419th ,,	55th Div.	N.E.	
422nd ,,	,,	,,	
423rd ,,	,,	,,	
XI CORPS.			
59th Field Co.	5th Div.	E.	
491st ,,	,,	,,	
527th ,,	,,	,,	
7th ,,	50th Div.	,,	
446th ,,	,,	,,	
447th ,,	,,	,,	
400th ,,	51st Div.	,,	
401st ,,	,,	,,	
404th ,,	,,	,,	
476th ,,	61st Div.	,,	
478th ,,	,,	,,	
479th ,,	,,	,,	

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HAZEBROUCK. 12TH-15TH MARCH, 1918.

Unit.	Formation.		Remarks.
XV CORPS.			
2nd Field Sqn.	2nd Cav. Div.	D.	
455th Field Co.	29th Div.	E.	
497th ,,	,,	N.E.	With 88th Inf. Bde.
510th ,,	,,	E.	
210th ,,	31st Div.	,,	
211th ,,	,,	,,	
223rd ,,	,,	,,	
11th ,,	33rd Div.	,,	
212th ,,	,,	N.E.	
222nd ,,	,,	,,	
207th ,,	34th Div.	,,	
208th ,,	,,	D.	
209th ,,	,,	N.E.	
224th ,,	40th Div.	E.	
229th ,,	,,	,,	
231st ,,	,,	,,	
1st Aust. Field Co.	1st Aust. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	

SIGNALS.

HAZEBROUCK. 12TH-15TH APRIL, 1918.

Unit.	Formation.	Remarks.
First Army Signal Co.		N.E.
" A " Corps Signal Co.	I Corps	E.
3rd Divl. Signal Co.	,,	,,
4th ,,	,,	,,
55th ,,	,,	D.
L. Corps Signal Co.	XI Corps	,,
5th Divl. Signal Co.	,,	E.
50th ,,	,,	,,
51st ,,	,,	,,
61st ,,	,,	,,
P. Corps Signal Co.	XV Corps	D.
29th Divl. Signal Co.	,,	E.
31st ,,	,,	,,
33rd ,,	,,	D.
34th ,,	,,	E.
40th ,,	,,	,,
1st Aust. ,,	,,	,,

BAILLEUL. 13TH-15TH APRIL, 1918.

Unit.	Formation.		Remarks.
SECOND ARMY.			
ARMY TROOPS.			
No. 2 Special (Mortar) Co.	IX Corps	E.	
42nd Army Troops Co.	XXII ,,	N.E.	
133rd ,,	XXII ,,	,,	
134th ,,	IX ,,	E.	
136th ,,	XXII ,,	D.	No diary.
167th ,,	IX ,,	N.E.	
235th ,,	VIII ,,	E.	
557th ,,	VIII ,,	,,	
1st Aust. ,,	IX ,,	,,	
171st Tunnelling Co.		,,	

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BAILLEUL: 13TH-15TH APRIL, 1918.

Unit:	Formation:		Remarks:
184th Tunnelling Co.	IX Corps	N.E.	
255th ,,	IX ,,	E.	No diary.
3rd Can. ,,		,,	
No. 351 E. & M. Co.	XXII Corps	D.	
No. 8 Foreway Co.	,,	,,	No diary.
No. 9 ,,	,,	,,	No diary.
IX CORPS.			
81st Field Co.	19th Div.	E.	
82nd ,,	,,	,,	
94th ,,	,,	,,	
105th ,,	25th Div.	,,	
106th ,,	,,	,,	
130th ,,	,,	,,	
207th ,,	34th Div.	,,	
208th ,,	,,	,,	
209th ,,	,,	,,	
57th ,,	49th Div.	,,	
456th ,,	,,	,,	
458th ,,	,,	,,	
467th ,,	59th Div.	,,	
469th ,,	,,	,,	
470th ,,	,,	,,	
97th ,,	21st Div.	N.E.	
98th ,,	,,	,,	
126th ,,	,,	,,	
XXII CORPS.			
63rd Field Co.	9th Div.	E.	
64th ,,	,,	,,	
90th ,,	,,	,,	
XV CORPS.			
455th Field Co.	29th Div.	N.E.	
497th ,,	,,	E.	With 88th Inf. Bde.
510th ,,	,,	N.E.	
11th ,,	33rd Div.	,,	
212th ,,	,,	E.	
222nd ,,	,,	,,	

SIGNALS.

BAILLEUL. 13TH-15TH APRIL, 1918.

Unit.	Formation.		Remarks.
Second Army Signal Co.		N.E.	
" E " Corps Signal Co.	IX Corps	D.	
19th Divl. Signal Co.	,,	E.	
25th ,,	,,	,,	
34th ,,	,,	,,	
49th ,,	,,	,,	
59th ,,	,,	,,	
21st ,,	,,	D.	
33rd ,,	XV Corps	E.	
Y Corps Signal Co.	XXII Corps	D.	
9th Divl. Signal Co.	,,	E.	

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KEMMEL (FIRST BATTLE). 17TH-19TH APRIL, 1918.

Unit.	Formation.		Remarks.
SECOND ARMY.			
ARMY TROOPS.			
No. 2 (Special) Mortar Co.	IX Corps	N.E.	
42nd Army Troops Co.	XXII ,,	E.	
133rd ,,	XXII ,,	N.E.	
134th ,,	IX ,,	E.	
136th ,,	XXII ,,	D.	No diary.
167th ,,	IX ,,	N.E.	
235th ,,	VIII ,,	E.	
557th ,,	VIII ,,	,,	
1st Aust. ,,	IX ,,	,,	
171st Tunnelling Co.		D.	
184th ,,	IX Corps	N.E.	
255th ,,	IX ,,	D.	No diary.
3rd Can. ,,	IX ,,	E.	
No. 9 Foreways Co.	XXII ,,	D.	No diary.
IX CORPS.			
81st Field Co.	19th Div.	E.	
82nd ,,	,,	,,	
94th ,,	,,	,,	
105th ,,	25th Div.	,,	
106th ,,	,,	,,	
130th ,,	,,	,,	
11th ,,	33rd Div.	,,	
212th ,,	,,	,,	
222nd ,,	,,	,,	
207th ,,	34th Div.	,,	
208th ,,	,,	,,	
209th ,,	,,	,,	
57th ,,	49th Div.	,,	
456th ,,	,,	,,	
458th ,,	,,	,,	
467th ,,	59th Div.	,,	
469th ,,	,,	,,	
470th ,,	,,	,,	
455th ,,	29th Div.	N.E.	
497th ,,	,,	E.	With 88th Inf. Bde.
510th ,,	,,	N.E.	
XXII CORPS.			
63rd Field Co.	9th Div.	E.	
64th ,,	,,	,,	
90th ,,	,,	N.E.	
225th ,,	39th Div.	,,	
227th ,,	,,	,,	
234th ,,	,,	,,	
97th ,,	21st Div.	,,	
98th ,,	,,	,,	
126th ,,	,,	,,	

SIGNALS.

KEMMEL (FIRST BATTLE). 17TH-19TH APRIL, 1918.

Unit.	Formation.	Remarks.
Second Army Signal Co.		N.E.
E. Corps Signal Co.	IX Corps	D.
19th Divl. Signal Co.	,,	E.
25th ,,	,,	,,
33rd ,,	,,	,,
34th ,,	,,	,,
49th ,,	,,	,,
59th ,,	,,	,,

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SIGNALS.

KEMMEL (FIRST BATTLE). 17-19TH APRIL, 1918.

Unit.	Formation	Remarks.
Y. Corps Signal Co.	XXII Corps	D.
9th Divl. Signal Co.	,,	E.
39th ,,	,,	N.E.
21st ,,	,,	,,

KEMMEL (SECOND BATTLE). 25TH-26TH APRIL, 1918.

Unit.	Formation.	Remarks.
SECOND ARMY.		
ARMY TROOPS.		
42nd Army Troops Co.	XXII Corps	E.
133rd ,,	XXII ,,	D.
134th ,,	IX ,,	E.
136th ,,	XXII ,,	D.
138th ,,	II ,,	N.E.
141st ,,		,,
235th ,,	VIII ,,	,,
289th ,,	II ,,	,,
557th ,,	VIII ,,	,,
1st Aust. ,,	IX ,,	E.
171st Tunnelling Co.	XXII ,,	D.
XXII CORPS.		
63rd Field Co.	9th Div.	E.
64th ,,	,,	,,
90th ,,	,,	,,
97th ,,	21st Div.	,,
98th ,,	,,	,,
126th ,,	,,	,,
105th ,,	25th Div.	N.E.
106th ,,	,,	,,
130th ,,	,,	,,
225th ,,	39th Div.	,,
227th ,,	,,	,, Employed under VIII Corps
234th ,,	,,	,, Employed under VIII Corps
57th ,,	49th Div.	E.
456th ,,	,,	,,
458th ,,	,,	,,
12th ,,	6th Div.	,,
459th ,,	,,	,,
509th ,,	,,	D.
200th ,,	30th Div.	,, Attached 49th Div.
201st ,,	,,	,, Attached 49th Div.
202nd ,,	,,	E.

SIGNALS.

KEMMEL (SECOND BATTLE). 25TH-26TH APRIL, 1918.

Unit.	Formation.	Remarks.
2nd Army Signal Co.		N.E.
" Y " Corps Signal Co.	XXII Corps	D.
9th Divl. Dig. Co.	,,	E.
21st ,,	,,	,,
25th ,,	,,	,,
39th ,,	,,	N.E.
49th ,,	,,	E.
6th ,,	,,	D.
30th ,,	,,	N.E.

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BÉTHUNE. 18TH APRIL, 1918.

Unit.	Formation.	Remarks.
FIRST ARMY.		
ARMY TROOPS.		
"D" Special (Cylinder) Co.	XI Corps	N.E.
No. 1 Special (Mortar) Co.	XI ,,	,,
148th Army Troops Co.	I ,,	,,
230th ,,	XI ,,	,,
552nd ,,	XI ,,	,,
560th ,,	I ,,	D.
170th Tunnelling Co.	I ,,	,,
250th ,,	XI ,,	N.E.
251st ,,	I ,,	E.
No. 10 Foreway Co.	I ,,	N.E.
I CORPS.		
23rd Field Co.	1st Div.	E.
26th ,,	,,	,,
409th ,,	,,	,,
56th ,,	3rd Div.	,,
438th ,,	,,	,,
529th ,,	,,	,,
9th ,,	4th Div.	,,
406th ,,	,,	,,
526th ,,	,,	,,
XI CORPS.		
476th Field Co.	61st Div.	E.
478th ,,	,,	,,
479th ,,	,,	,,
400th ,,	51st Div.	N.E.
401st ,,	,,	E. With 154th Inf. Bde.
404th ,,	,,	N.E.

SIGNALS.

BÉTHUNE. 18TH APRIL, 1918.

Unit.	Formation.	Remarks.
First Army Signal Co.		N.E.
"A" Corps Signal Co.	I Corps	,,
1st Divl. Signal Co.	,,	E.
3rd ,,	,,	D.
4th ,,	,,	E.
L. Corps Signal Co.	XI Corps	D.
61st Divl. Signal Co.	,,	,,
51st ,,	,,	N.E.

SCHERPENBERG. 29TH APRIL, 1918.

Unit.	Formation.	Remarks.
SECOND ARMY.		
ARMY TROOPS.		
20th Army Troops Co.	II Corps	D.
42nd ,,	XXII ,,	E.
133rd ,,	XXII ,,	D.
134th ,,		E.
136th ,,	XXII Corps	N.E. No diary.
138th ,,	II ,,	,,
141st ,,		,,
235th ,,	VIII Corps	,,
289th ,,	II ,,	,,
557th ,,	VIII ,,	,,
1st Aust. ,,	VIII ,,	,,

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SCHERPENBERG. 29TH APRIL, 1918.

Unit.	Formation.		Remarks.
171st Tunnelling Co.		D.	
258th ,,	VIII Corps.	N.E.	
No. 8 Foreway Co.	XXII ,,	E.	No diary. With 42 A.T.Co.
No. 9 ,,	XXII ,,	,,	No diary. With 42 A.T.Co.
No. 351 E. & M. Co.	XXII ,,	N.E.	
XXII CORPS.			
12th Field Co.	6th Div.	E.	
459th ,,	,,	,,	
509th ,,	,,	N.E.	
97th ,,	21st Div.	E.	
98th ,,	,,	,,	
126th ,,	,,	,,	
105th ,,	25th Div.	,,	
106th ,,	,,	N.E.	
130th ,,	,,	E.	
225th ,,	39th Div.	N.E.	
227th ,,	,,	,,	
234th ,,	,,	,,	
57th ,,	49th Div.	E.	
456th ,,	,,	N.E.	
458th ,,	,,	E.	
63rd ,,	9th Div.	E.	Under 49th Div.
64th ,,	,,	N.E.	
90th ,,	,,	,,	
VIII CORPS.			
200th Field Co.	30th Div.	N.E.	
201st ,,	,,	,,	
202nd ,,	,,	E.	
II CORPS.			
228th Field Co.	41st Div.	D.	
233rd ,,	,,	N.E.	
237th ,,	,,	D.	

SIGNALS.
SCHERPENBERG. 29TH APRIL, 1918.

Unit.	Formation.	Remarks.
2nd Army Signal Co.		N.E.
"Y" Corps Signal Co.	XXII Corps	,,
6th Divl. Signal Co.	,,	E.
21st ,,	,,	,,
25th ,,	,,	,,
39th ,,	,,	N.E.
49th ,,	,,	E.
30th ,,	,,	N.E.
9th ,,	,,	,,

AISNE, 27TH MAY-6TH JUNE, 1918.

Unit.	Formation.	Remarks.
IX CORPS.		
245th Army Troops Co.	IX Corps	E.
2nd Field Co.	8th Div.	,,
15th ,,	,,	,,
490th ,,	,,	,,
81st ,,	19th Div.	,,
82nd ,,	,,	,,
94th ,,	,,	,,
97th ,,	21st Div.	,,
98th ,,	,,	,,
126th ,,	,,	,,

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AISNE. 27TH MAY-6TH JUNE, 1918.

Unit.	Formation.		Remarks.
105th Field Co.	25th Div.	,,	
106th ,,	,,	,,	
130th ,,	,,	,,	
7th ,,	50th Div.	,,	
446th ,,	,,	,,	
447th ,,	,,	,,	

SIGNALS.
AISNE, 27TH MAY-6TH JUNE, 1918.

Unit.	Formation.		Remarks.
E. Corps Signal Co.	IX Corps	E.	
8th Dvl. Signal Co.	,,	,,	
19th ,,	,,	,,	
21st ,,	,,	,,	
25th ,,	,,	,,	
50th ,,	,,	,,	

N.B.—"MARNE, 1918" COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN THE BATTLE OF SOISSONNAIS-OURCQ AND TARDENOIS.

SOISSONNAIS-OURCQ, 23RD JULY-2ND AUGUST, 1918.

Unit.	Formation.		Remarks.
73rd Field Co.	15th Div.	E.	Under XX French Corps.
74th ,,	,,	,,	
91st ,,	,,	,,	
207th ,,	34th Div.	,,	Under XXX French Corps.
208th ,,	,,	,,	
209th ,,	,,	,,	

SIGNALS.
SOISSONNAIS-OURCQ, 23RD JULY-2ND AUGUST, 1918.

Unit.	Formation.		Remarks.
15th Divl. Signal Co.	15th Div.	E.	Under XX French Corps.
34th ,,	34th Div.	,,	Under XXX French Corps.

TARDENOIS, 20TH-31ST JULY, 1918.

Unit.	Formation.		Remarks.
XXII Corps (under 5th French Army).			
400th Field Co.	51st Div.	E.	
401st ,,	,,	,,	
404th ,,	,,	N.E.	Bridging just south of area.
457th ,,	62nd Div.	E.	
460th ,,	,,	,,	
461st ,,	,,	,,	

SIGNALS.
TARDENOIS, 20TH-31ST JULY, 1918.

Unit.	Formation.		Remarks.
"Y" Corps Signal Co.	XXII Corps	D.	
51st Divl. Signal Co.	51st Div.	E.	
62nd ,,	62nd Div.	,,	

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AN UNOFFICIAL HISTORY OF THE SIGNAL SERVICE WITH THE BRITISH SALONIKA FORCE, 1915-18.

(*Concluded.*)

By CAPTAIN C. C. S. WHITE, M.B.E., R.E.

JULY TO SEPTEMBER, 1918.

FINAL ATTACK, SEPTEMBER, 1918.

During the month of June, 1918, the Greek Army was steadily being brought into the line, and two Divisions were already holding a portion of the Struma front under the British. The 27th Division moved from the Struma to the west bank of the Vardar, and took over from the 122nd French Division. Their Divisional Headquarters at Drevino was in direct communication with G.H.Q. in Salonika, as well as with the XII Corps at Janes, by good permanent lines constructed earlier in the year. This Division opened the final offensive by capturing some two miles of the Bulgar positions to a depth of 1,000 yards on the hills west of the Vardar, and so dominated Gevgheli.

It soon became clear that a grand offensive was imminent. Preparations were made for strengthening advanced lines. The XVI Corps moved from the Struma to Snevce in August. The health of the Signals Service personnel was extremely good considering the time of the year. Units as a whole were only 100 below establishment at the end of August.

On September 12th the I Greek Corps of three Divisions, which was now directly under the orders of British G.H.Q., was holding the Struma front. The XVI Corps Headquarters was near Snevce, with a Report Centre at Sal Grec de Popovo. This Corps was now composed of the 28th Division and the Greek Cretan Division.

General Milne's advanced H.Q. was near Ismali. The XII Corps Report Centre was on Piton Rocheux, opposite the "Pip" ridge and "Grand Couronne." This Corps was now composed of the 22nd and 26th Divisions and the Greek Seres Division. The 27th Division was on the west bank of the Vardar overlooking Gevgheli, as already mentioned.

The line was prolonged to the west by more Greeks, the Serbs on the Cerna River, the French near Monastir, and the Italians in Albania.

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Opposing us there were at that time the Eleventh German Army in Albania (composed chiefly of General Pflanzer-Baltin's Austrian Corps, a large number of Bulgarian troops and a smattering of Germans).

In the centre, from a point almost due north of Monastir to the Vardar River, was the First Bulgarian Army. To the east the Second Bulgarian Army held from the Vardar River to the Gulf of Orfano. All the Turkish troops had been withdrawn from the front in the summer of 1917.

The general plan of our attack was founded on the experience of previous Balkan campaigns, more particularly the Greek campaign of 1913 against Bulgaria, and was simplicity itself. The main attack was to come in the centre opposite the Dobropolje, on a comparatively small front of 15 miles. If a complete break-through were effected, the attack was to be extended on either flank from the north-west of Monastir to the Vardar, involving all the central position of our line on a 70-mile front. Everything depended on the rapid advance of the spear head of the attack, which position of honour was entrusted to the Serbian Army. Concurrently with the attack in the centre, an attack had been planned on the right, to be undertaken by the Anglo-Greek forces on both sides of Lake Doiran, with the object of immobilizing the Second Bulgarian Army, and preventing them detaching troops to the assistance of the First Army in the centre.

The attack by the Serbs and the French on the Cerna front commenced at dawn on Sunday, September 15th, when the Bulgar positions were successfully stormed with comparatively slight losses, and the advance into the Bulgar position was energetically pushed forward. The attack by the British and the Greeks on the Doiran position was launched at 5 a.m. on Wednesday, September 18th. The attack on the " Pip " ridge was unsuccessful. The Seres Greek Division captured Doiran town, Teton Hill and the Petit Couronne. The Greek Cretan Division attacked between Doiran Lake and the Belashitza Range, but the Bulgar position was not penetrated. The casualties on both sides were extremely heavy.

No information was obtained for several hours from the British troops attacking the " Pip " Ridge, as all the advanced cable lines were cut by artillery fire, and the pigeons which were to have been taken had been left behind.

The Seres Division, however, took 36 carrier pigeons from a semi-mobile loft, which had been erected a fortnight previously at Piton Rocheaux, the advanced XII Corps Headquarters. These birds came back well from 7 a.m. onwards, and 12 of them brought back useful information by noon. The wording of these messages could not always be taken too literally; one of them ran "We have 200 prisoners— send us some more bombs."

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The Serbian advance on Prilep and Krivolak was reported to be progressing very satisfactorily.

On Thursday, September 19th, the attack was resumed at 5.20 a.m., with fresh British troops, while the Seres Division attacked and advanced well up the slopes of the Grand Couronne; but owing to our failure to secure "Pip" Ridge on the left, this position became untenable, and on the afternoon of the 19th the engagement was broken off, so we consolidated our gains of the previous day. Although we had only slightly advanced, we had succeeded in pinning down the Bulgar to his position. Not a man nor a gun was detached to assist the First Bulgarian Army.

Meanwhile the Serbs were still continuing their advance, and on September 20th, they were approaching the Vardar, north of Mirovene.

Pursuit into Bulgaria.

At mid-day on September 21st, came the cheering news that the Serbs had cut the enemy lines of communication up the valley of the Vardar, at Demir-Kapu—the Iron Gates—the exact spot where the Greeks cut it in 1913. As a result of this only an immediate retreat from the Doiran position could save the Bulgar from utter disaster; furthermore his only line of retreat was along the road which runs north of Doiran Lake, through Hasanli Dedeli and Robrovo, up the steep pass of Kosturino on to the broad plateau which forms part of the extreme west of the Belashitza mountains, then down again on to the Strumitza Plain. This road was in good repair as far as Robrovo, but the section from there to Strumitza was never intended for use as a main communication; it was tortuous and steep and very lightly metalled.

The Bulgars evacuated their main position on the night of the 21st/22nd September. The pursuit was taken up forthwith by the British cavalry. All units were on the move early on the 22nd. The two Corps changed over. This was inevitable, as the two Divisions now forming the XII Corps—the 22nd and the 28th—had been reduced to skeleton formations, the former by the attack, the latter through sickness. The XVI Corps was now composed of the Cavalry, the 26th Division, the 27th Division from the west bank of the Vardar, and the 14th Greek Division hastily summoned from the south. General Briggs, the Corps Commander, was relentless in his pursuit. The cavalry kept touch with the enemy throughout; they were closely supported by the 26th Division.

On the third day, September 24th, the Bulgars were driven up the Kosturino Pass, being ruthlessly bombed and machine gunned all the way by the R.A.F., who wrought devastating havoc amongst them, and turned their retreat into a hopeless rout.

The Derbyshire Yeomanry entered Bulgaria at Kosturino on the 25th, whilst units of the 22nd and 28th Divisions, assisted by Greek

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troops, attained the summit of the Belashitza. The XVI Corps advanced Report Centre* (QRC) was established at Furka, and was in communication with 16th Corps Headquarters (QCO) and G.H.Q., by a composite line of cable, standard airline and permanent line (both enemy and our own), through Bogdanci, Stojakovo, Smol and Vergetor, this being the road, or rather track, along which the Corps had advanced. As the track was very indefinite through "No Man's Land," great care was taken to place the airline as far out of reach as possible, and so this line lasted, as the sole means of communication with our advanced Corps, until the Army Signal Company replaced it, on September 28th, by a four-wire permanent route along the main road through Doiran Town to the Dedeli Pass.

On Thursday, September 26th, our advanced troops captured Strumitza. QRC moved to Popecvo, having advanced 35 miles in 4 days. QCO moved to Furka; throughout the advance they were only one day's march behind QRC, General Brigg's Report Centre.

The XII Corps established their Report Centre, MRC at Border Hill.

The 28th Division and the Greeks were working their way eastward along the Belashitza Ridge.

The Army Signals, Nos. 1 and 60 Airline Sections and A.H. Cable Section, were hard at work building an eight-wire route through the old "No Man's Land," to bridge the gap of some ten miles between the British system and the German-Bulgar system of permanent lines, and so complete four pairs of wires for the proposed move of Army Headquarters to Cestovo. No 39 Motor Airline Section was sent up by the L. of C. Signal Company to assist.

About a month before the attack, one of the Airline Sections (No. 38), attached to the XVI Corps Signals, was converted from Horse to Motor Transport. This proved a great asset in the advance, as this section was able to push ahead with its lorries, and prepare ten to fifteen miles of wires during the day, and so keep the Corps

*NOTE.—Signal Offices take their call signs from the Headquarters that they represent. Battalions use their Regimental abbreviations suffixed by a letter of the alphabet to indicate the number of their battalion, thus:

HAMJ	10th Battn, of the Hampshire Regiment.
RIRF	6th Battn, Royal Irish Rifles.

Divisions and Brigades use the letters Y and Z respectively prefixed by a letter denoting their number; their report centres add the letter R, thus:

YJ	10th Division.
YBGR	27th Division Report Centre.
ZBI	29th Brigade.

Corps and Army Headquarters are denoted by the letters CO and AR, whilst their report centres change these into RC and CP respectively, thus:

MCO	XII Corps Headquarters.
QRC	XVI Corps Report Centre.
SAR	Salonika Army Headquarters.
SCP	Salonika Army Command Post.

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Commander at QRC in telephonic and telegraphic communication with the remainder of his staff at QCO each night. The policy adopted by the Chief Signal Officer, XVI Corps, was to join through the two *top* wires on the Bulgarian routes, labelling them carefully at all junctions, and making good gaps with airline. The top wires are usually the best wires on a route, and can be safely assumed to be the " through " trunk lines from town to town ; in this particular case they were 200-lb. copper wire, in excellent condition, except where they had been intentionally demolished. A definite decision such as this saves considerable confusion to those who come after. When this was not done, the Army Signals experienced unnecessary trouble, caused by linemen, who had a tendency to take a narrow partisan view of inter-communication problems, chopping the lines about with regard only to their immediate requirements.

The following instances give some idea of the wear imposed by the rough roads on the M.T. vehicles, and the remarkable way in which they withstood it. On one occasion the engine of a Ford van fell out—one of the rear supporting lugs fractured—when the car was 40 miles from camp, so it was lashed to the chassis with eight strands of 200-lb. G.I. wire. This not only carried the car home, but also a further 120 miles back to the Base M.T. Depot. On another occasion one of the Dennis lorries, of No. 38 Airline, was sent down from Sveti Vrac to Salonika, over a hundred and fifty miles of rough and hilly roads. When it arrived, the tyre was removed from one of the back wheels, whereupon the wheel fell into 37 pieces. The O.C. of the Base M.T. Depot sent for the two drivers of the lorry and congratulated them.

During the next four days, fighting took place on the hills to the north of Strumitza, and to the east along the valley, in the direction of Petric, where the upper Struma and the Strumitza valleys join. Considerable resistance was met with near Yenikoj (about half-way between Strumitza and Petric). The XVI Corps moved into Strumitza on the 27th, and on to Dabilja on the 28th. In the meantime Bulgar delegates had passed through our lines to sue for peace. The armistice was signed on the 29th, and came into effect at midday on September 30th, 1918.

On the morning of the 30th, the 26th Division was only 15 miles away from the only line of communication (which runs through the Rupel Pass and up to the Struma valley), open to the Bulgarian Corps operating in the lower Struma. Had it not been for the armistice it is probable that the whole of their force would have had to lay down its arms.

So ended an advance of some 60 miles in 8 days, undertaken by an Army that had been fighting for three years in an extremely difficult country.

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OCCUPATION OF BULGARIA.

However, this was by no means the end for the British Salonika Force, and for Signals in particular. The XVI Corps Signals were fortunate in being able to use the Bulgar permanent lines, which were in excellent condition, and ran along their old, and our new lines of communications. Immediately after the armistice, No. 38 Airline Section went through the Bulgar line to repair the two top wires where they had been cut by shell-fire, ready for the next move of advanced Corps Headquarters to a point 14 kilometres west of Petric. When they returned to camp at Dabilja that night they discovered they had joined QRC direct through to 2nd Bulgarian Army Headquarters at Sveti Vrac.

By the conditions of the military convention with Bulgaria, the Allies were to be given every facility for the transport of our troops in their country. The British Army was originally to occupy Sofia, and the whole of Bulgaria as far as Widin on the Danube. With this intention in view QRC moved from Dabilja, on October 5th, down the Strumitza valley, and across the Struma to Sveti Vrac, a little village on the edge of a forest, where the Bulgar Second Army had established their headquarters. They had built most palatial residences, which were cleverly concealed by the trees. There were at least two hundred bedrooms, offices, and officers' messes, all fitted with electric light and an ample water supply; as well as three or four suites, completely furnished, for the Army Commander and the Chiefs-of-Staff. In addition to all this, there were the Turkish Baths! The Bulgars had made use of a natural hot spring of sulphuric water, which came out of the ground at 200°F This they diverted into the bath house, which comprised a series of small swimming baths, each hotter than the other.

The ultimate policy of G.H.Q. was not to use the Strumitza L. of C., which consisted of a very lightly metalled road from Doiran to Yenikoj, that would break up entirely as soon as the rain came, but to press on with the reconstruction of the railway from Doiran to Vetrina Bridge, at the southern entrance of the Rupel Pass, and to use the Bulgar Decauville railway from there to Radomir and Sofia. So Army Signals started to build an eight-wire permanent route alongside the railway to Vetrina Bridge, where they established a Signal Office. Progress, however, was slow, owing to transport difficulties and the necessity of clearing the route of trees and scrub. Furthermore, as Sections were required for construction of other lines, on account of the move eastwards against Turkey, it was decided to reduce the number of wires to four and arm the railway poles, thus saving the erection of a new line of poles through very wooded country.

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Move East against Turkey.

On October 11th it was decided that the British and the Greek Armies, under the supreme command of General Milne, were to move east against Turkey.

The XII Corps (22nd and 28th Divisions), moved to Stavros, whence they were to embark for Dedeagatch, and gradually take up positions along the River Maritsa, which formed the Turko-Bulgarian frontier from Adrianople to the sea, whilst the Greeks marched to this same line through their lost province of Eastern Macedonia, which the Bulgars immediately evacuated under the terms of the armistice.

The XVI Corps (26th and 27th Divisions) marched up the Struma Valley along the main Sofia road, to a point just south of the Kresna Pass, where the infantry entrained on the Decauville railway, built during the war by the Bulgar, for Radomir, a town twenty-five miles south of Sofia, through which the main Berlin-Constantinople railway runs. At Radomir they re-entrained on the broad gauge, and went through Sofia to Mustapha Pasha (or Svilengrad), the frontier town opposite Adrianople, on the Maritsa. The gunners and all horse transport entrained at Kostenets; mechanical transport went by road all the way through Dubnitza, Samakov, Kostenets, Phillipopolis and to Mustapha Pasha—a distance of 260 miles.

Lieut.-Colonel C. H. Prickett, D.S.O., R.E. (Chief Signal Officer XVI Corps), was placed in charge of all Signal communications east of Strumitza and north of Vetrina Bridge, on October 12th. He was responsible for maintaining communications from Strumitza and Vetrina up to XVI Corps Headquarters (QCO), from there to QRC., and to the 26th and 27th Divisions during their march up the Struma Valley and on to the Bulgarian frontier at Mustapha Pasha. He proceeded to Sofia and interviewed M. Nedlekoff, the Bulgarian Minister of Posts and Telegraphs, who issued instructions to all telegraph offices along our route to give every assistance to all British Signals, which they most certainly did.

Colonel Prickett opened a Signal office and telephone exchange in the British Legation at Sofia. The Bulgars lead in their main telephone line to Sv Vrac, and also the eastern side of the German Berlin-Constantinople telephone line. Double-current Duplex Telegraph was superimposed on both these telephone circuits. Telephone speech from Sofia to Sv Vrac and Salonika was excellent.

QRC moved via Kostenets, and arrived at Svilengrad on September 20th. The Headquarters of the XVI Corps Signal Coy. moved there by train, and No. 38 Motor Airline Section went by road from Sv Vrac, 240 miles in 5 days.

The German telephone line from Berlin to Constantinople was built of the very finest material during the war, evidently for

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propaganda as well as for military purposes. It consisted of two 400-lb. copper wires on very large porcelain insulators. From Sofia it ran on the Bulgarian State telephone route alongside the railway as far as Papasli, where it branched off and followed the road to Adrianople on 14 metre poles of its own; the two wires were run as an inside pair on an 8-way arm, and had test points conveniently arranged about every two miles. We used it for a magneto ringing telephone circuit with telegraph superimposed from Svilengrad to Sofia, and a telephone intermediate at Kostenets, a distance of some 200 odd miles, and the telephone speech was absolutely perfect throughout.

On October 25th, the whole of the 26th Division had reached Svilengrad, and all arrangements had been made for an immediate attack on Adrianople. This, unfortunately, never matured, as the Turks capitulated on October 30th, 1918.

Meanwhile, Colonel A. H. W. Grubb, C.M.G., D.S.O. (Signal Officer in Chief), was concerned with the difficult problem of communications to Dedeagatch, in readiness for the arrival of the XII Corps. There was a good British line as far as Kilo. 69 on the Seres Road; an indifferent line to Kilo. 71; and thence nothing over "No Man's Land" and the Struma plain for 20 kilometres, to Seres. From Seres there had been, in the old days, the Turkish Constantinople-Drama-Seres-Salonika telegraph route. This was, however, largely destroyed, and it was found that most of the wires were being taken into use by the Greeks. The telegraph line along the railway was found standing from Nihor (5 miles S.E. of Seres) to Angista, which had been the Bulgar railhead, and there appeared to be several wires available along the railway to the east.

Time was of paramount importance, so it was decided to use the Seres Road route as far as Kilo. 71, and to build a new permanent route of two pairs of Z9 wire from there to Seres, which was to be our railhead, and from there to repair and use two wires along the railway route. From Seres, one through telegraph wire would be provided for Dedeagatch, and a separate wire for intermediate places, Drama, Xanthi, Gumuldzina, etc.

Two motor airline sections were immediately put on to the construction of the line from Kilo. 71 along the Seres Road as far as the railway crossing, and thence along the railway to Seres station. No. 4 Airline Section was brought down from XVI Corps, and the Airline Sections from XII Corps were also employed. Standard airline and cable were laid from Kilo. 80, via Seres town to Topoljani, and communication established to that place by 22.15 hours on 16th October. The repairs to the line as far as Drama were completed by October 18th, and a Morse set was installed there working to Salonika—thus establishing a telegraph line of 160 kilometres in 6 days.

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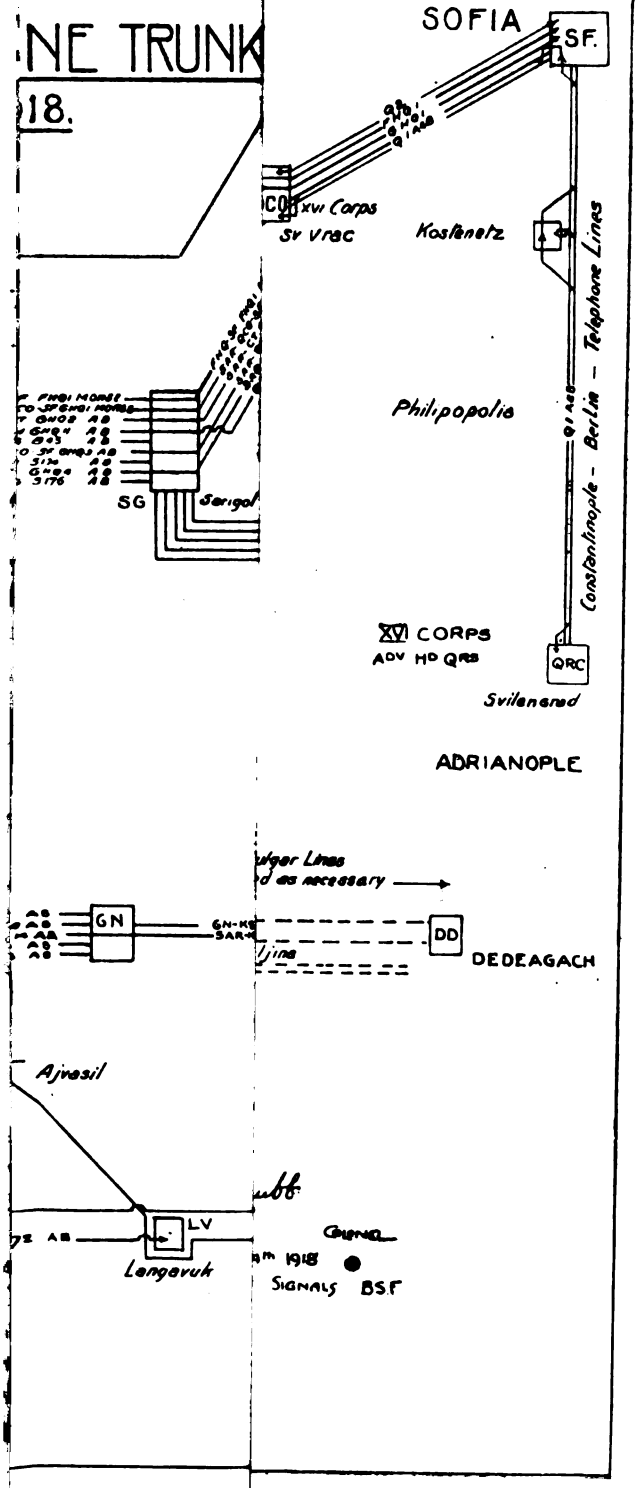
Plate IV



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On October 22nd, No. 3 Airline Section reached Xanthi, and established a Morse and telephone Signal Office there. Two wires on the railway route were demanded from the Bulgars for communication to Dedeagatch. Certain changes were necessary in the Bulgar railway communications to place the desired wires at the disposal of the British, and the Bulgars were somewhat reluctant to do this. So the Signal Officer in Chief proceeded to Xanthi to deal with the matter in person, and when he made it clear that the British Signals were in a position to take complete control, the Bulgars acquiesced, and one top railway wire was handed over, the second to follow in a few days when the British were ready for it. On October 28th, the advanced detachment of No. 1 Airline Section reached Dedeagatch and opened a Signal Office at 19.00 hours with Morse communication to Gumuldzina, and thence to Drama, and Salonika. The advanced party of XII Corps Signals, with a wagon wireless station, landed that afternoon. Although this line was "through" there was still a great deal of work to be done, cutting out temporary repairs and clearing the line of trees and "earths" generally. Large parties were employed on this work until its completion. A diagram of telegraph and telephone routes on this date is given on Plate IV.

Occupation of Constantinople.

The Armistice with Turkey, which was signed on October 30th, on board H.M.S. "Agamemnon," at Mudros, put an end to any military operations on the river Maritsa. Nevertheless it meant a long programme of work for Signals, as a division (the 28th) was to be sent to the Dardanelles. The XII Corps Staff were to go to Constantinople, the 26th Division was to join the Army of the Danube. The 22nd and 27th Divisions were stopped and brought back to Stavros and Salonika.

The XII Corps Signals opened an office at Dimotika on November 4th, and steps were taken to push on telegraph lines to Adrianople, for communication to Constantinople.

Commander W. H. Cottrell, R.N.V.R., established communication to Constantinople on November 8th, via Eastern Telegraph Company's cables and Turkish land lines through Smyrna.

On November 9th, General Sir H. F. M. Wilson, with a portion of his Staff and XII Corps Signal Company, embarked at Dedeagatch for Constantinople. The XVI Corps Headquarters started to move from Svilengrad to Janesh; the 26th Division to Ruschuk.

The news of the signing of the armistice with Germany was received by wireless at 09.30 hours (07.30 hours Paris time), and was immediately circulated to all signal offices, where it was displayed in large letters over the usual wireless news, which was habitually posted daily outside signal offices on special notice boards.

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XII Corps Headquarters arrived at Constantinople on November 12th, and were in communication with Salonika, via Smyrna, as already mentioned. Official messages took from three to ten hours in transmission.

Army Signals opened a signal office at Adrianople on November 17th, and established direct telegraph communication from Sofia to Constantinople at 21.15 hours. The next day direct telegraph communication was established between Salonika and Constantinople at 17.00 hours. There were at first six offices on this line, which was 450 miles long. Although there were no translating relays in circuit, the signals were quite good.

Lieut.-Colonel H. C. Saunders, D.S.O., R.E., and the party of XII Corps Signals that landed in Constantinople on November 12th, immediately opened a signal office (CN) in the Grand Rue de Pera, took over the wireless stations at Osmanie and Ok Meidan, and closed the German Signal Office in Constantinople. The XII Corps Signal Company was re-named the Allied Force Headquarters Signal Company. During the remainder of the month they did an immense amount of work, mostly on local lines and the direct lines which were put through to Salonika on November 18th.

As regards telephones in Constantinople, we were in an ideal position, because the *Société Ottomane Téléphonique*, whose staff was composed largely of old National Telephone Company engineers, had installed a very complete system of paper insulated underground cables radiating from their exchanges at Pera, Stamboul, and in the suburbs. These lines were all in good condition as they were working Central Battery system telephones. They terminated in junction boxes, containing from 5 to 30 pairs, conveniently situated on the walls of houses about 15 feet from the ground. From these boxes twisted V.I.R. cables were run to the various telephones in the vicinity. In the centre of the city there was a box every 50 to 100 yards, and there were plenty of spare pairs in each box. All the lines and boxes were clearly numbered, and recorded at Pera Exchange. M. Papasien, the Chief Engineer at Pera, an Armenian who remained loyal to the Company during the German occupation of Constantinople, had kept everything in as good order as he possibly could, and on our arrival was of the greatest assistance to us. We installed a 100-line Magneto Switchboard, with a British operator, in his Test Room at Pera, and then ran a pair of D5 cables to the nearest junction box, whilst he made the necessary connections on the jumper frame.

On November 16th, Signals Sofia established communication from his office over Bulgar lines to the 26th Division at Ruschuk.

An advance party of G.H.Q. Signals opened the G.H.Q. Signal Office (TAR) in the Turkish Military School at Constantinople.

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on December 7th. They also opened a Signal Office (PA) in the old German Signal Office, which was in the same building as the Eastern Telegraph Company's office, and so very convenient for working on their cables and the Turkish telegraph lines. They gradually took over the work started by XII Corps Signals. All the lines in the Salonika area were handed over to the L. of C. Signal Company, and by the end of the month the whole of the G.H.Q. Signal Company had moved to Constantinople.

The Eastern Telegraph Company's cable from Syria, via Tenedos and Chanak, was put through to Constantinople at 21.00 hours on December 17th. This gave us direct communication with the 28th Division in the Dardanelles, as well as alternative line to Salonika.

The E.T.C's cable to Odessa was put through by December 29th. Communication was established from there to Ekaterinodar, via Rostov, but this was soon interrupted by the Bolsheviks.

The German cable to Constanza was restored in January.

When the 26th Division moved to Varna, the line from Sofia to Ruschuk was extended by another Bulgar line to Varna. This was perfectly satisfactory, and messages were sent to them via Sofia. Generally speaking, it was found that Russian telegraph lines (in the Caucasus) and lines in Bulgaria worked considerably better than any lines we took over in Turkey.

By February 1st it was possible to work Wheatstone on the Salonika-Constantinople direct line, which was then carrying something like 20,000 words per day. The reason for this colossal amount of traffic was that the post took three days each way.

A route diagram of these and other lines is appended Plate V.

The Caucasus and South Russia.

In the middle of December, 1918, Captain P. A. Hitchcock, M.C., R.E., and 16 other ranks from the Allied Force Headquarters Signal Company, Constantinople, embarked for Batoum, they formed the nucleus of what eventually developed into the Caucasus Signal Company. There was an existing land line to Batoum from Constantinople, via Kastamuni, Sinope, Samsun and Trebizond. Arrangements were made with the Turkish authorities to join this line through to the British signal offices at Pera and Batoum for certain periods each day. There were two translating relays, at Samsun and Trebizond respectively, which were adjusted by Turkish operators. The line was 700 miles long, and in a somewhat precarious condition. It was, however, possible to work single current Morse at a rate of eight to twelve words per minute; above this speed the signals were distorted by the capacity of the line.

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By the end of the year the 27th Division had reached Batoum, where they left one Brigade. Divisional Headquarters and the other two Brigades proceeded to Tiflis, and from there on into Armenia. Their role was to stop the war which was being waged between Georgia and Armenia. Unfortunately, time and space do not permit any further account of the interesting experiences of Signals in the Caucasus. Let it suffice to mention that communication was established to Baku, which was occupied by the 39th Brigade, which had reached there from Persia, and across the Caspian Sea to Kradnovodsk, down along the railway to Kars, Erivan, Tabriz, and eventually, for a short time, by the Indo-European Telegraph line to Karachi and Bombay.

The Army Wireless Company, who had taken over the German high-powered Wireless Station at Osmanie, just outside Constantinople, established a station at Novrossisk, and so maintained communication with the Mission sent to the assistance of General Deniken in South Russia. At Tiflis the existing Russian station was reorganised and opened up for communication with Constantinople, Batoum, Baku and Basra, while a set was installed at Batoum, as an alternative to the land line to Constantinople, and as an additional means of communication with the Russian Mission, in case of failure of the cable via Odessa.

Osmanie proved useful both to the Navy and Army by transmitting a large amount of traffic to Malta and thus relieving congestion on the cables.

It will have been noticed how the work of the Signal service changed rapidly after the capitulation of Bulgaria in September, 1918. Field lines, buzzer and visual signalling dropped out almost entirely, and gave place to telegraph and telephone working over long distant permanent lines. It was only by the experience of this type of work gained by officers and men whilst in Salonika, and the previous experience of several of all ranks who had been in the Postal Telegraph Service at home, that it was possible to put in order, maintain and operate these long trunk communications.

So ends the history of the Signals of the British Salonika Force, which started with no lines at all, and finished up with lines from Athens to Tabriz.

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M. G. O. E.

TECHNICAL EXAMINATION BRANCH FOR R.E.SERVICES ITS INCEPTION, HISTORY AND FUNCTIONS.

By COLONEL D. M. F. HOYSTED, D.S.O.

FOR some little time previous to 1910, it had been felt by responsible R.E. Officers that the authorised method of carrying out Works Services and the Incidental care of W.D. Property was not wholly satisfactory, and that the Army was not obtaining the best possible value for the public funds allocated to those works.

The writer's previous experience in the North Aldershot Division had probably been matched in many other stations.

The Field Company, in which he was a newly-joined subaltern, after a year's experience at the Curragh, was moved to Stanhope Lines: the Company was on the lower establishment and the numbers were so depleted that, when the Sappers were on parade and the specially employed men had been dismissed, it was difficult for the uninitiated to tell whether the dismounted portion was advancing in line or moving to a flank in fours. The Captain was placed in charge of the North Aldershot Division, and when we arrived to take over, we found that our predecessors had already left the station, and we were informed by the Division Clerk that we need not expect to stay long, as the Division officers were changed every couple of months or so.

The writer was much impressed at the time by the long hours worked and the faithful service rendered by the Military Foremen of Works, upon whose shoulders nearly all the Divisional work seemed to have lain hitherto. It is a worthy tribute to them that we found that the work was flowing on satisfactorily without let or hindrance under the circumstances which formed our experience. There was not the faintest hint of misplaced confidence.

Responsibility sat lightly on the D.O. and the Sub-D.O. in those days; indeed, upon some others it seemed to sit more lightly still. A works bill had merely to satisfy the Paymaster, and then it probably languished among the cobwebs for a period of years before being finally disposed of.

But as it became realised in high places that many R.E. Divisions never had a chance of the blessings of continuity in organization, a Committee was appointed by the Secretary of State for War in 1910 to enquire into and report upon the best means of improving this

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undesirable state of affairs. Their report was issued in due course, and one result was a proposal for the institution of a strict audit of all Works Services from a technical as well as a financial standpoint, the further to increase efficiency and economy.

At first it was suggested that the staff for this duty should be under the direct control of the Financial Secretary, in order to establish its entire independence, and that its duty should be to post-audit in detail such proportion of the Contractor's bills as might be deemed desirable, such audit to include test measurements, with power to call for all plans, specifications and estimates at any stage of the work, and also to check measurements during the actual progress of the work, if considered advisable. The Committee attached the very greatest importance to this recommendation, as only a check of this nature could bring home responsibility, which was the underlying principle they had in mind. It was felt that most of the defects of the existing system had been seriously aggravated by the absence of such outside and independent examination.

After many conferences and discussions it was decided to bring into being a small Technical Audit Branch, and to ensure its absolute independence of action, without divorcing it entirely from all touch with the Branch responsible for the execution of R.E. Works Services, it was placed, not under the Finance Members, but under the M.G.O., so as to function as a separate Branch independent of his Directorates.

The new Branch was to operate under a Chief Technical Auditor, and the first holder of the directing post was to be Col. Stuart Davidson, C.B.E. (late R.E.), who was specially selected because of his intimate knowledge and experience of Works Services and for his keen discrimination, which would enable him to establish the necessarily somewhat difficult relations between his staff and the Directorates of other Branches, whose bills would come under his review. It was stated that the duties of the new Branch would be taken up gradually and the staff expanded to keep pace with the added business of audit.

As a beginning, the Director of Establishments (C. 4) was asked to supply one clerk, an ex-R.E., who had served as R.E. Clerk in a Division Office as well as in a C.R.E.'s Office, who was a competent typist, and could organize the clerical work of the Branch. As an item of interest, he has been with us until the end of last year.

The necessary Treasury sanction was received in due course, and on the 18th September, 1913, the Secretary to the War Office issued a circular to all Commands notifying the G.O's.C. that a separate Branch of the War Office had been created, under the M.G.O., for the purpose of undertaking the technical examination of Works services. The title was altered from "Technical Audit" to "Technical Examination Branch," and its principal duties were stated to be :—

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A. To visit works and make examinations of Works expenditure.

B. To test measurements during the progress of the work.

C. To examine bills for Works Services from a technical point of view after payment.

The duty of the Branch was to test whether the quantity and quality of the various classes of work set forth in the particulars (Bills of Quantities, Schedule of Prices, Measurements, &c.), on which payment is claimed, do, in fact, fairly represent the quantity and quality of the work actually executed. It was intended that the Branch should carry out its duties in close touch with the Local Audit Staff of the Command. It was also explained that the functions of the Branch do not interfere with the free exercise of the powers of the G.O.C. and his subordinates, nor relieve them from their respective responsibilities in regard to Works Services, nor do they include any enquiry into the suitability of the designs, specifications, &c., nor any examination of the quality of the workmanship or materials, except in so far as may be necessary to determine whether the proper description or Schedule Item is quoted and the proper price charged under the contract. But, in the event of the quality of the workmanship or the materials being in dispute, the Branch will pay special attention to this point.

At the end of 1913 and the commencement of 1914, the procedure to be followed was hammered out by the C.T.E. to the satisfaction of the Finance andAccounts Branches, and the new Branch began to function with one Command; the idea being that the remaining Commands should be drawn in as the C.T.E. gained the necessary experience, and as the Treasury authorised the required increase of staff.

As technical errors began to come to light, and it was found that varying sums of money were due to or from the Works Contractors in consequence, the question of re-adjustment came under consideration. This was not envisaged in the initial procedure, which was not intended to relieve in any way the local staff from its responsibility for the correctness of Works bills passed for payment. It was felt that the T. E. Branch was not meant to form part of the ordinary machinery for checking the correctness of Works bills, but to be a separate and independent means of testing whether the ordinary machinery was working efficiently. It followed that, beyond pointing them out for future guidance, no action was originally contemplated for re-adjustment of minor mistakes discovered in the course of the scrutiny, unless they were so numerous as to raise the query of inefficiency or carelessness, or were of such a character as to involve important principles.

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Later on, the inevitable alternative to the recovery from a contractor of an overpayment, when such reparation was refused by him or denied by the terms of the contract, suggested itself in the form of penalising the responsible officer or W.D. employé who could not give a satisfactory explanation of the cause of the blunder. It was provided that, in such cases, the whole controversy should pass from the purview of the Examination Branch to the G.O.C. the Command, who could take such disciplinary action as he thought fit. Later on, the disorganising effect of such a system was demonstrated and the public was forced to be content with restitution from the Contractor, as it was everywhere realised that mistakes in such technical matters are due to errors of judgment or want of experience rather than to other causes.

Before August, 1914, the staff was increased to :—

1 Chief Examiner, 2 Examiners, 2 Assistant Examiners, 3 Surveyors' Clerks, and 2 Clerks ; but after the outbreak of war the numbers were gradually increased to :—

1 Chief Examiner, 2 Examiners, 6 Assistant Examiners, 15 Surveyors' Clerks, and 2 Clerks.

This large increase was due to the growing volume of work entailed in the measuring, abstracting, checking, etc., of the various encampments constructed for the occupation of the New Armies. After the signing of the armistice the staff was progressively decreased till the pre-war establishment shown in the above paragraph was reached early in 1919, and has remained at that number, which is less than half the size originally contemplated.

During the Great War the staff of the Technical Examination Branch was asked to assist in reporting upon works in progress, especially those large building schemes for camps which were undertaken on the agency system. This duty was of a most onerous and unpleasant nature, as the methods sometimes accepted by the local authorities concerned, in order to save time, as they thought, were too often the cause of large and preventable expense, while their anxiety to provide the accommodation at an early date was sometimes abused by biased persons, with the result that some processes were open to the most strenuous objection.

As a consequence of these extraneous duties, the post-audit of bills began to fall into arrears. And as bills were at times not received by the C.T.E. for a year or so after payment, steps became essential to make up the leeway that had gradually accumulated. This lag was so marked at one time that a suggestion was made for all bills previous to April, 1919, to be neglected, and a fresh start made on bills paid after that date. Happily this hiatus was rendered unneedful after a conference held at the W.O. on 2nd June, 1920. The Schedule of Prices was revised, responsibility for the accuracy of bills was re-notified to Commands and alterations were made in the initiation of

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abstract and bill, as in the recognised procedure for checking and signing them throughout their passage. As an example of the delays that often occurred at this period, the following may serve :—

Date of completion of Service	1.10.15.
Bill signed by contractor	10.5.16. . . . 7 months
Bill signed by D:O.R.E.	20.2.17. . . . 9 months
Bill signed by C.R.E.	24.7.18. . . 17 months
Bill recd. by C.T.E.	2.20. . . . . 19 months

The gross amount of this bill was over £3,000; the nett amount, however, was nil, as the contractor had already been overpaid on account during the progress of the work. One of the unsatisfactory results of such delay is the natural tendency to pass a long outstanding account eventually without proper check, which may, indeed, have become almost impracticable owing to changes in personnel and other circumstances.

The number of bills which had to be examined each year during the war was very large, involving expenditure running into millions. At the same time, contracts were so loosely framed that the percentage of total overpayments actually recovered from contractors in 1919-20 was only 11%. As a basis of comparison, the report for the half-year ending 31st March, 1926, discloses recoveries obtained which yield a ratio of nearly 50%. To give full value to this improvement it should be realised that the amounts recovered can never rise to balance the overpayments concerned, because in so many cases recovery is barred by the terms of the contract.

It will have been seen that the total time that had elapsed between the actual completion of the work and the receipt by the C.T.E. of the bill mentioned above was four years and five months. At a conference in 1920 it was stated that the average time for this journey was anything up to eighteen months. To-day it is nearer five months, which will be still further reduced in the near future. A suggestion has often been made that the labours of the Branch would be of greater value if the system of post-audit were changed to some form of check dealing with current work, and thus rendering expert assistance available to executive officers: but this was not at all the opinion of the Committee which brought about the formation of the Branch. It was undoubtedly and whole-heartedly brought into being to fulfil a long-felt want by providing a technico-financial check, thorough, and therefore not subject to a time limit, and having some of the following subjects :-

A. The enforcement of correct and economical procedure in regard to the execution of contracts, measurements, pricing and works accounting generally.

B. To promote a reasonable appreciation of their responsibilities in these respects in those persons immediately concerned.

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C. To bring to light and point out errors and excuses for future guidance in similar debatable queries.

D. The prevention of collusion.

E. The deterrent effect upon contractors and others, who know that even when an account has been purposely left till the end of the financial year, and then successfully hurried through to payment on a carefully conceived psychological plan, that same account will come up for scrutiny of which the essence is care, and under conditions which do not depend on time.

F. To keep foremen of works up to the mark.

As post-audit is its object, the staff may be a comparatively small one and need not interfere in any way with the free hand of C.E's. and C.R.E's. in deciding details of their schemes; whereas, if its duties hinged on pre-audit, it must of necessity be large, in order to keep pace with a vaster amount of work, and, furthermore, it could not fail to undermine the responsibilities of the local authority. This design is apparent from the chief defects of the system in vogue before the introduction of the present method of examination after payment, i.e., that the old system was ineffective because it was insufficiently thorough, and it was impossible to carry out a pre-audit sufficiently comprehensive and conclusive without delaying the payment of bills to a prohibitive extent, and without vastly increasing the staff.

Another vital requisite for the technical Branch was to secure independence of opinion, together with adequate support. Though working in close touch with the D.F.W., the D.B.C. and the Works Finance Branch, it could not act under the orders of either of them without sacrificing that wholly unbiassed and unrestricted purpose, the rock upon which its very being is founded. All these indispensible characteristics were secured by placing it directly under the Master General of the Ordnance.

One of the first tests applied to a new service is the financial one, and what is looked for is the resulting financial saving, which expression is eagerly pounced upon by critics when that saving is meagre in terms of sterling, in their attempt to demonstrate the ultimate debit balance due to the Branch. But it is obvious that this financial balance cannot be expressed in figures alone, and it must be realised that such examples as can be quoted here do not form the true criterion of the ultimate saving in money, when considered apart from all other factors, such as losses due to overcharge which have been prevented.

It is true that the only direct financial saving lies in the sums recovered from contractors. But this really subordinate point was not even considered amidst the reasons which occasioned the birth of the Branch; indeed, it is not so very long ago when the recovery of overpayments was not even provided for amongst the terms of the old Triennial Contract. At the present moment it is definitely legalised

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only in the Term Contract for Artificer's Works, a descendant of the older agreement. It is excluded from the other contract forms for R.E. Works after payment of the final bill.

The value of re-imbursement from contractors rests less in the amounts recovered, which are often individually small, than in the deterrent effect of the reminder to the contractor that his computations have not only to pass the local staff, or escape their notice when hurried through at the end of the financial year, but are subject to detailed investigation by independent expert technical examiners. This also forms a further protection against the possibility of collusion between persons responsible for the initiation of the bill, who are themselves experts.

On the other hand, indeed, contractors are beginning to realise that adjustment under the terms of the agreement will also be made when they have been underpaid, and this impartiality of restitution is bound to have its beneficial repercussion in the acceptance, on more favourable terms, of future contracts for Works.

When affairs had begun to resume their normal state after the war, there arose a desire that some form of results should be produced and published, both to indicate the lines on which progress was being made, and to ensure that the experience gained might be placed at the disposal of the originators of future bills for Works Services. The information culled from the errors of others might thus be made use of so that the subsequent volume of observations might ever be on the wane. The method arrived at by a process of exclusion consisted of a comparative table of percentages showing the comparison between the number of observations made and the number of bills selected for examination. And this hope of the committee is being steadily realised, since the general value of appreciable errors has diminished very considerably. Attempts are being made to consider results from the positive view point, and show the percentage of accurate bills to the total, a method that may produce a more satisfactory impression. It is very difficult to show a direct measurement of the improvement in the general position which has resulted from the suggestion of the Committee, nor is it possible to average the percentage figures over longer periods than the half year, because the areas and importance of districts have varied considerably from time to time, and have not even yet settled down to their final conditions.

It is therefore impossible to work out and maintain a convincing "batting average" for districts. It would only be correct for the United Kingdom as a whole, since the secession of the stations in Southern Ireland, and even then is subject to the confusion occasioned by the residue of War Services which are gradually being closed down.

At present the scope of the examination is confined to Works in the United Kingdom, though it is felt that all stations abroad might,

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with advantage, be embraced gradually in the organization. A beginning is to be made with the Far Eastern Stations as from 1st March, 1927.

Some years ago, when the volume of bills was very large, the percentage that could be checked by the small staff authorised was much less than it is now. Consequently, the number of bills with errors that remained unchecked was relatively greater, and the only errors that could be observed upon were for relatively larger amounts. Now that the total of bills received is smaller, approximately equal to pre-war days, the percentage checked has gone up considerably, for the staff, though small, has remained constant.

As a consequence, the number of errors which remain unchecked has diminished appreciably, and it follows that the check is more severe. The sieve has a smaller mesh, and the average financial value of an error is correspondingly less. The efficiency of the check and the satisfactory results in financial terms are, therefore, increasing, though this may lead the sufferer to cavil at what he deems a pinprick: in fact, observations involving trifling financial errors are only made to draw attention to some principle which appears to have been overlooked. But it also points to a much more desirable conclusion, namely, that the number of errors is curtailed, and we are obtaining better value for our money. This in itself is a cause for rejoicing, especially during the lean years through which we are called upon to pass.

Medical officers who look after the health of great cities pride themselves most when the incidence of disease and epidemic is at a minimum. Their efficiency is in inverse proportion to the amount of disorder. Similarly, the smaller the total of street accidents, the more competent is the traffic control. The less talk of disease and misadventure, the more efficacious must be the unseen work of these preventive organisations. Even in the last four years the maximum percentage of total observations to number of bills examined, for single districts, has fallen from nearly 600 to 100, and should soon sink below the 50 line. And the percentage, in monetary value, of total expenditure on R.E. Services, to the bills observed upon, i.e., the measure of health of the community, has already been raised to a very large figure, while the total number of Observations is gradually falling.

Now, the conditions of Works Contracts are ever so much more complicated abroad than they are at home, which naturally increases the opportunity for error. If, therefore, all bills from foreign stations were also subjected to technical check, similar beneficial results would be attained for those stations, and a further increase of return would be ensured for the funds available.

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THE COAL PROBLEM AND LOW TEMPERATURE DISTILLATION.

By CAPTAIN G. MACLEOD ROSS, M.C., M.ENG., A.M.INST.C.E., R.E.

The possession of vast natural resources of coal, amounting, it is estimated, to no less than a further 1,000 years' supply at present rates of consumption, has been the basis of the industrial prosperity enjoyed by this country throughout the nineteenth century. Since the year 1800, when only 10,000,000 tons of coal were raised, until 1913, the peak year of coal production, when 287,000,000 tons were mined, the coal industry has gradually expanded. Since the conclusion of the war it has fallen on evil days, and the state of depression has naturally been reflected in the many trades and industries which rely on coal.

Expressed in military terms, the coal industry of Great Britain is at a low ebb, because it lacks an up-to-date doctrine, and consequently it cannot produce the coal at a price to meet the economic demand.

During the war the mines were to all intents and purposes nationalized, and it can be said in mitigation of the present plight of the industry that this had the effect of blinding it to the conditions which would pertain, and under which it would have to operate, when the controls, which are alone possible and effective in war, were raised.

The average individual is rather apt to lay the cause for the comparatively sudden failure of the coal industry to run on economic lines at the door of oil fuel. The report of the Royal Commission on the Coal Industry [1] has indicated that this is far from being the whole truth. Here it is clearly shown that the main source of trouble lies in our export trade, which has dropped from 98,000,000 tons in 1913 to 43,750,000 tons in 1920. Of this decrease, only 3,000,000 tons is attributable to the change-over to oil fuel. Foreign consumers of coal are not using less than they did in 1913; on the contrary, their consumption has in most cases increased. Nor is this decrease in export trade due to the vast development in the use of electricity and the utilization of water power resources abroad. The main reason for our depression is that other European countries have now, through force of war circumstances, become largely self-supporting, which means that they can raise coal within their own territory more cheaply than we can supply it.

1 Cmd. 2,600.

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It will, therefore, be clear that the consideration of any new process whereby coal can be changed into a gas, an oil and a solid fuel, is of universal interest. On the commercial success of such a process the coal industry may legitimately look for an increase in the demand for coal, with the consequent increase in price which such a demand will create, whilst the industries of the country may look for a lessening of their fuel bill.

The foregoing aspect is, of course, of importance to the Fighting Services of the country; nevertheless, it is the possibility of obtaining from native sources the fuel on which the Services rely for their mobility that makes the problem a peculiarly personal one.

The distillation of coal readily falls into the two categories of high and low temperature processes. The former is in the hands of the coke oven and gas industries, which between them carbonize annually some 37,000 000 tons of coal to obtain, principally, metallurgical coke and town gas. The by-products of these processes are tar, sulphate of ammonia, and sulphur.

Low-temperature carbonization processes are undoubtedly those which, of late years, have attracted most attention in this country. Speaking at a luncheon on October 20, 1926, given by the Institution of Fuel Economy Engineers, Sir Robert Horne referred to a process of low-temperature carbonization of coal by which might be obtained liquid fuel and oil, together with gas of a high calorific value, and a residuum of solid fuel of special value.

Motor spirit, Diesel oil, and fuel oil are obtainable by this process, and Great Britain might thereby become independent of the well oil imported from foreign countries. This would mean fewer chances of political misunderstanding leading to war, and a possible reduction of defensive commitments necessary to preserve the source of imported oil, and safeguard the line of supply in time of peace. In war it would mean increased independence of action for all the fighting services, since the source of fuel would be at home.

The gas and the solid fuel obtainable are mainly of interest from an industrial and domestic point of view. The possibility immediately arises for the bulk generation of gas at the collieries, and its distribution by means of high pressure long-distance mains [2] to the chief industrial and agricultural areas. When such distribution in this country comes to be considered, it is found that in no case need a single transmission line be more than 75 miles in length to reach the various areas from the adjacent coalfields. Such an undertaking, although unknown in this country, has been successfully practised in America and Germany for some years. In Westphalia, since 1913, a pipe-line 270 miles long, and ranging in diameter from 16 in. to 8 in., has supplied 2,500,000 people. In the United States, the

2 Article in "Gas Journal," 10/2/26.—"Gas Supply in Bulk by Long Distance Transmission," by Harald Nielsen.

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Western United Gas and Electric Company, of Aurora, Illinois, has a high pressure main 85 miles long, supplying a distribution system of 1,300 miles of pipe line, the maximum pressure used being 95 pounds per square inch.

At the present time, when much is being heard about super-power stations and long-distance transmission, it is interesting to compare how much more favourably the gas industry stands as regards the problem of long-distance high pressure transmission than does the electricity supply industry. The main obstacle to high-tension, long-distance electricity transmission is not only that the main high tension feeder must be provided, but that the low tension distribution system in countless villages and towns has to be built up. It is this aspect of the electrical case which is utilized by opponents of the super-power stations' scheme to show that the country is not yet ready for such treatment, and that before it can be a commercial success the small power station must be exploited to do the spade work of providing the low tension distribution system, after which the high tension transmission line, supplied from a super-power station, will come into its own.

Now the gas industry already possesses all over the country the necessary low pressure distribution systems, and the time is therefore ripe for high pressure gas distribution, should gas generation in bulk at the coal-fields prove practicable as a result of the establishment of some form of low temperature process.

The solid fuel resulting from low temperature carbonization is of such a nature that it will burn in the domestic fireplace without the emission of smoke and, consequently, it offers by its use to improve the amenities of life in our cities. In Manchester the cost of household washing on account of smoke is estimated at £290,000 per annum. The Coal Commission estimated that 3,000,000 tons of soot are discharged into the atmosphere of the British Isles annually, equivalent to 3,000,000 men-days per annum of coal production.

There are also possibilities to be derived from the use of the solid fuel in pulverized form. Owing to its freedom from hard graphitic carbon films, the fuel requires less power to pulverize it than either coal or high temperature coke. Its low volatile content means a possible reduction in the size of the combustion chamber, whilst it possesses a noticeably low ash content which does not fuse. It compares favourably with pulverized coal as regards bulk, and has a calorific value of from 11,000 to 12,000 B.T.U. per lb., depending on the coal from which it is carbonized.

So far no low temperature process has been established on a commercial scale for a period sufficient to enable the claims made on its behalf to be fully tested. Unfortunately, the impression has arisen that it is only necessary to choose the best process, establish it on every coalfield and immediately the air will be cleared,

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not only of soot, but of every industrial and domestic fuel problem. This is far from being the case, and the longer the subject is studied, the clearer it becomes that low temperature distillation, like most other industries and processes, will have to be evolved gradually.

The complexity of the commercial problem is to be gathered in part from a consideration of what has befallen the Westphalian high-pressure gas plant. The contracts for the supply of gas were made, having as their price basis the normal requirements and development of the steel trade for oven coke. With the slump in the steel trade came an increase in the gas demand, resulting in the gas having to be supplied at a loss. Here, at once, is the danger in a process which produces oil, gas and coke. At one period the gas may satisfactorily be made to pay for the loss on the oil, but a change in the national requirements may suddenly render the whole process uneconomical.

In order that a distillation process may be a lasting success, it is essential that all three products shall be self-supporting, and that there shall be no making up on the roundabouts the losses on the swings.

It is now proposed to describe at some length a representative carbonization process.

THE L. & N. PROCESS.

Whilst high temperature processes work around 1,000° C., the low temperature processes vary from 400° C. to 600° C.

It is quite impossible to define what exactly constitutes a low temperature process, since the numerous self-styled low temperature processes all work at different temperatures, and all produce different results. Some concentrate on producing fuel of a certain calorific value, whilst others are mainly interested in the resulting gas. The types of retort employed are as variegated as the products evolved ; some are externally heated, others use internal heat ; one passes steam over with a view to temperature control, whilst others employ paddles to stir up the coal dust and so ensure even heating.

From such an array it is not, however, difficult to appreciate the plant which is simplest and most efficient, having in view the desired end. Nor is it difficult to pick out the system which is capable of expansion to a commercial scale, and therefore capable of handling a large throughput of coal.

The first fact that bears on the system of retorting employed is the penetration rate of heat in coal. At 200° C. to 250° C. this is found to be 0.75 to 1.0 inch per hour. Taking this fact in conjunction with the observation that oil commences to be liberated from bituminous coals at from 200° C. to 220° C., and that above 450° C. no further oil evolution occurs, it is clear that whilst temperature control is likely to be very difficult to effect, it will be facilitated by using small or slack coal and surrounding it with hot inert gases. The economic effect of this is obvious, since low priced slack and smalls

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will readily lend themselves to low temperature treatment with little or no expense being incurred for crushing.

The " L. & N." demonstration retort consists of a rotating tubular furnace, 45 ft. long by 3 ft. 6 in. diameter, very similar to that employed in the cement making industry. It is suitably lined with fire brick and fitted with staggered shelves, which turn over the fuel as the retort revolves. The retort is mounted with a slight fall along its length from the hopper end, where the coal is fed in, towards the combustion chamber end. Slack coal is fed in to the retort continuously by means of a suitably sealed screw feed.

The capacity of the demonstration retort is 8 to 10 tons per 24 hours, but it is intended that the commercial unit should be 100 tons per diem, estimated to cost complete £25,000. Speaking generally, gas for firing is supplied by a water gas producer, and is fed into the combustion chamber to which secondary air is fed. The combusted gases pass under a baffle wall, after which a definite amount of gas from the final scrubbers is added, together with a small quantity of steam. The scrubber gas combines with any free oxygen and provides a means of temperature control. The inert gases then pass to the retort at about 700° C., and the normal temperature gradient along the retort is :—At 17 ft. from the point of gas admission, 420° C. At 27 ft., 320° C. At 34 ft., 250° C. Outlet temperature 150° C. to 180° C. The pressure loss in the retort is negligible.

From the retort the distilled gases first pass to a dust extractor, next through two annular coolers, then to a water cooler and condenser. A fan is interposed here to do the necessary exhausting. Passing this, the gases go through a final water cooler and, lastly, to two coke scrubbers. This gradual cooling is employed in order to ensure that no chemical decomposition of the oils carried over as vapour ensues.

The products per ton of raw fuel are approximately 15 to 20 gallons of oil, 2,000 to 3,500 cubic feet of gas of varying calorific value, depending on the retorting system, and 0.6 to 0.65 ton of residual fuel.

It should be noted that, depending on the products desired, the process of retorting will be altered accordingly.

As regards the gas, three main grades can be produced by the process :—

a. A producer gas enriched by the distillation gases to a calorific value of 200 to 230 B.T.U. per cubic ft., suitable for furnace work, steel manufacture, and general industrial purposes.

b. A carburetted water gas. Calorific value 360 to 380 B.T.U. per cubic ft. Suitable for town gas purposes as a diluent or for industrial or manufacturing processes.

c A distillation gas of calorific value of 500 B.T.U. per cubic ft., suitable for enriching town gas, or for long distance

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transmission, or in a compressed state for welding and cutting to replace acetylene.

Whilst in each case above mentioned the quantity of the remaining fuel is altered, the quantity and quality of the oil obtained remains unimpaired. In the production of the last mentioned distillation gas, it has been found possible to move the temperature zone of the retort, in which the oil vapour is distilled off, nearer to the point of exit of this vapour. The temperature at the combustion chamber end of the retort is raised so that the gradually advancing coal, having given up the oils in a temperature which is sufficiently low to ensure that no decomposition takes place, is finally introduced into a zone at a temperature of some 900° C., in which it gives off an additional quantity of gas. The gas first removed from the coal is mixed with the gas given up by the residual fuel, the mixture amounting to approximately 7,900 to 8,450 cubic feet per ton of coal carbonized, and having a calorific value of from 495 to 515 B.T.U. per cubic ft., depending on the type of bituminous coal used.

The table below summarizes the laboratory results :

	Scottish Non-coking No. I.		Barnsley Coking No. II.		Doncaster Coking No. III.	
	Gas from Coal.	Gas from Coke.	Gas from Coal.	Gas from Coke.	Gas from Coal.	Gas from Coke.
Cal. Value B.T.U. per cubic foot	730	436	675	394	675	392
Vol (in cubic ft.) per ton of coal ..	2000	5500	3300	4800	2200	4000
Distilling Temp. ..	550°C.	900°C.	550°C.	900°C.	550°C.	900°C.
Vol. of Mixture per ton of dry coal ..	8350 c.ft.		8450 c.ft.		7900 c.ft.	
Cal. Value of Mixture B.T.U. per c.ft. ..	515		507		495	
Oil obtained galls. per ton	21		17.5		21	

By this means a slur usually cast upon low temperature methods by town gas engineers is seen to be partially removed.

It will be readily understood that the gas therm is saleable at a higher price than the coke therm, and consequently from a gas engineer's point of view the test of a carbonization process is the ratio of therms in the gas and the coke—the price obtainable being from 8d. to 8½d. in gas form, and from 1d. to 1.2d. in coke. Town gas undertakings usually produce from 65 to 70 therms of gas per ton of coal carbonized. The normal low-temperature process gas gives only some 22 gas therms per ton of coal. By the method just described it is possible to raise this figure to 43 gas therms per ton of coal [3].

The residual fuel had a volatile content of from 1.5 to 2.0 per cent. only, but it was found to be very free burning and as easily ignitable as with a volatile content of from 8 to 10 per cent.

3 See Appendix.

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When producer gas is obtained, the volatile content of the fuel varies from 13.12% for Coal No. I., 10.15% for No. II, and 13.49% for No. III., the quantity of residual fuel varying from 0.6 to 0.65 ton per ton of coal. The residual fuel, although varying as to volatile content, is smokeless and eminently suitable for use in domestic grates, whilst the possibilities of burning it under boilers in pulverized form has already been mentioned.

It now remains to consider the oil which the " L. & N. " process produces. The claims put forward are that *true primary oils* are obtained, and the contention is supported by the fact that these oils conform to the tests laid down by Professor Franz Fischer, of Mulheim, for primary oils. In this, the " L. & N." process differs from many other low temperature processes. It is found that the quantity of crude oil obtainable per ton of bituminous coal amounts to from 15 to 20 gallons. The main points of interest regarding the oil are that all the distillates are of the paraffin series, whilst the product from bituminous coals is to all intents and purposes a standard, irrespective of district, coking, non-coking, younger or older coal formation. These primary products are the same, not only in specific gravity, but in relative percentage by weight of fractions and in physical properties. Consequently, not only are the primary oils amenable to the same refining treatment, but, when refined, they readily mix with well oils of similar properties.

That the lubricating oils obtained compare very favourably with highly-priced and well-known oils now on the market is borne out by tests carried out by the National Physical Laboratory at Teddington.

The quantities of refined oils obtained from a large scale test, per ton of Lambton (Durham) coal by the " L. & N." process are set out below :

Light burning oil	0.925 gallons.
Diesel oil	2.190 ,,
Light lubricating oil	1.890 ,,
Heavy lubricating oil	2.020 ,,
Acid oils	7.48 ,,

A total of 14.835 gallons of saleable oils [4].

However, it has been shown [5] experimentally that a further 40 gallons of motor spirit is obtainable from the fuel residuum by means of either the Fischer-Tropsch " Synthol " process or the Badische Catalytic process. The former process starts with the solid carbonaceous residue of the coal distillation from which water gas is obtained. Of the reaction product known as "Synthol" subsequently obtained, it is claimed that 80 % can be used as a motor spirit—the yield from the coke residue of a ton of low grade British bituminous coal, con-

4 Excludes the light spirit from Scrubbers which gives about 1.5 gallons of motor spirit per ton of coal distilled.

5 See articles in the "Gas Journal," June 16th, 23rd, and 30th, 1926, by Harald Nielsen.

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taining 7 to 8 per cent. ash and 5 to 6 per cent. moisture, being 40 gallons. Some of the properties of this refined " Synthol " are given as :

Specific gravity 0.828.

Nett calorific value 13,600 B.T.U. per lb.

Road tests give the following results :—

Kilos. run per 100 cc. " Synthol " 3.0

Benzole 2.9

Nett calorific value of Benzole used was 17,250 B.T.U. per lb.

An attempt has been made in the foregoing to give a connected account of one of the many processes which may help to solve our present fuel problem. Unfortunately, the commercial aspect, no less than the technical, is extremely involved. Before the former problem can be successfully realized, it is essential that the latter should be completely solved, and the crying need of the moment is for research on a scale of 12 inches to the foot.

It is clear that the primary distillation and the subsequent refinement or treatment in order to obtain the maximum yield of oils of all natures presents numberless problems, the solutions of which are in many cases interdependent, but in the tackling of which co-ordination is most necessary. The magnitude of the complete operation is clearly beyond the resources of a single private firm, and it is confidently to be hoped that the Fuel Research Committee recently set up by the Government will provide the necessary co-ordinative direction, and that the necessary research will be supported by Government funds

APPENDIX.

The percentage of available heat recovered in the normal High Temperature process is :

In the coke 56%

In the gas 28%

The percentage of available heat recovered in the normal "L. & N." process is :

In the residual fuel 71.5%

In the gas 8.3%

The relative thermal percentage as a result of this secondary treatment of the residual fuel is :

Heat in fuel residue 65%

Heat in mixed gas 14.8%

The relative commercial values of the two low temperature processes are, as 1 to 1.23.

The costs ratios of various fuels, taking the raw coal therm as unity and allowing for the greater average efficiency in converting the respective heat units into power, are :

Raw coal . . .	1.00	Diesel Oil . .	1.755	Town Gas . .	4.940
Fuel Oil	2.49	Petrol	6.475	Producer Gas	0.952

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THE STEREOSCOPIC EXAMINATION OF AIR PHOTOGRAPHS.

By LIEUT. M. HOTINE, R.E.

Anyone who has a pair of normal healthy eyes can get some sort of stereoscopic impression from a suitable pair of photographs. To appreciate small variations in relief, or to gauge the relative depths of land forms over considerable areas, are, however, matters which require a knowledge of the principles of the subject, a little practice, and some care in the selection and use of the stereoscope.

To the surveyor the subject is of some importance ; it is becoming increasingly apparent that he can do very little towards producing any sort of a map by modern methods of air survey without the use of some form of stereoscope, and he cannot know too much of the principles he is applying. At the same time air photographs will often be available for the use of the staff or regimental officer who merely wants to get a general idea of the lie of the land. To do so, he need have very little special knowledge, but it is all to the good if he can acquire, with little effort and as a matter of interest, sufficient information to enable him to know what he is doing. The purpose of this article is to steer a middle course between these two requirements. It will contain three lines of mathematics and only " looking glass " optics, and will succeed in its object if it arouses some spark of interest in the subject.

EXPOSURE CONDITIONS.

Any two photographs of the same stretch of country may be combined in a simple stereoscope to produce an impression of *relief*, provided they have been taken from different view points and in roughly the same plane. The *third dimension* supplied by the combination, or *fusion*, of the two pictures will then be perceptible in a direction at right angles to the common plane of the two photographs. This third dimension will, in future, be referred to as " depth."

To obtain a direct stereoscopic impression of vertical heights, the common plane of the two negatives at exposure must consequently be horizontal. This implies the use of a pair of " verticals " (that is photographs taken with the camera axis pointing vertically downwards), which shall moreover have been taken from an aeroplane flying at a constant height between the two exposures. The

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greater part of this article will deal with this, the commonest and most generally useful case, although the same principles are equally applicable to oblique or horizontal axis photographs.

The length of the *base* between the two camera stations will depend, among other things, on the altitude of the aeroplane, and the relative relief of the ground. If it is too small in relation to these two factors, the result will be a weak stereoscopic impression; if too long, various troubles arise in the subsequent examination of the photographs. We shall have occasion to refer later to these questions.

The necessity for the second negative of the pair to be exposed in the same plane as was the first will also appear later. Air photographs, taken on a base length of a mile or so, cannot at present be made to fulfil this condition rigorously, but they can be, in fact usually are, taken with ample accuracy for qualitative examination. For the purpose of instrumental air surveys it is often desirable for various reasons to expose in very different planes; but whether this condition is violated from choice or from necessity, it is at the root of all complexity in processes of photographic survey, where it is usually a question of the *measurement* of stereoscopic images. A complete remedy for the resulting troubles is only to be found in somewhat intricate machines, the main function of which is to reduce the two photographic images to a common equivalent plane, which moreover is usually one of the co-ordinate planes of the survey. For the moment, however, we are merely concerned with qualitative work, and we shall assume, justifiably, that this condition has been sufficiently well fulfilled for the purpose.

Now wherein lies the magic of such a pair of photographs? To answer this question it is necessary to invoke the aid of a little simple geometry.

Suppose that Fig. 1 represents the state of affairs at exposure; the centres of the photographs (or more correctly the plumb points) being at c and c^1. A point O on the ground, at a depth H below either position of the aeroplane, will give rise to images o and o^1 which occupy very different positions relative to c and c^1 on the pictures. The amount of this difference of position can be expressed by the algebraic difference o^1o^{11} of oc and o^1c^1. Designate this difference by the term "stereoscopic parallax,"* and call it p. A glance at a pair of similar triangles in the figure establishes our first line of mathematics, and the Genesis of Stereoscopy:—

* Exception may be taken to this expression for a linear measure on the ground of its confusion with the astronomical term "parallax," which is essentially an angle. In fact, some writers on the subject use the term "stereoscopic difference," for this reason. "Parallax" has, however, already taken such a grip on this branch of surveying that it is perhaps better to retain it.

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$$p = \frac{fb}{H} \qquad (1)$$

where b is the length of the *air base*, and f is the focal length of the camera lens (or more correctly the "principal distance" of the camera).

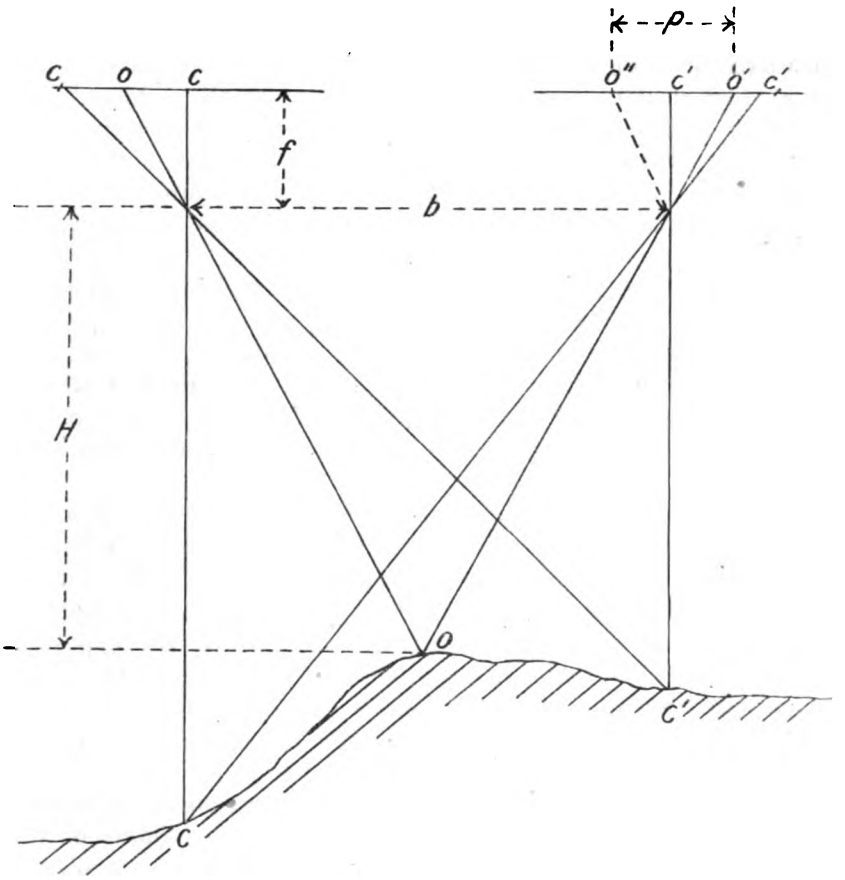

Fig. 1.

This simple relation between parallax, which can of course be measured on the photographs, and the corresponding depth of an object below the air base, would enable us to determine vertical heights, *provided* the above exposure conditions had been rigorously fulfilled. Further, objects on a particular contour for which H is constant, have a constant parallax, so that once the appropriate value of H or p has been determined the contour could be traced.

Now suppose that a dead flat plain is photographed, so that H, and consequently p, is constant all over the pictures. The two views will then be entirely similar, and indeed could have been obtained from the same air station by merely decentreing the camera

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lens. Such a pair will be found to yield *no* impression of depth in the stereoscope; as might be expected, they will combine to produce the impression of a dead flat plain, and *whatever the actual numerical parallax there will be no indication whatsoever as to the depth at which this plain as a whole lies.* In this particular case we are dealing solely with *absolute* parallax and we get *no* sensation of relief, so that it is quite safe to assume that *absolute* parallax has nothing whatever to do with the phenomenon. It is important to get this idea fixed once and for all. Failure to appreciate the point has led to a great deal of nonsense being written on the subject. For instance, it has been asserted that stereoscopic fusion becomes impossible where parallax exceeds a certain amount, and that in consequence it is necessary to use short bases in order to reduce parallax. This is to throw away one of the greatest advantages of photographic survey from the air.

On the other hand it will be found that a stereoscopic impression is invariably obtained where a sufficient *difference* of parallax exists between various images, that is, where the two pictures are *dissimilar* in form. The whole effect is in fact entirely relative; we do not, cannot, estimate the absolute depth of a single object stereoscopically; we can only *compare* its depth with that of a neighbouring object.

The more of this *difference* of parallax we obtain, under practical conditions, for a given *difference* in heights on the ground, the better will be the subsequent stereoscopic effect. The mathematician will at once take this hint to *differentiate* the above formula to see how this end may be attained by varying the exposure conditions. Other things being equal, he will find that the stereoscopic effect can be increased by:—

(*a*) using a long focal length.
or (*b*) increasing the base length.
or (*c*) flying low, in which case the increment in parallax difference varies inversely as the *square* of the reduced flying height.

These mathematical conclusions are entirely supported by practical results, but there are nevertheless other controlling factors. A long focal length implies a bigger and heavier camera, or alternatively a restricted field, and will seldom be permissible in survey operations, where economy in time or money is so essential. The base length for a given height is fixed independently of all other considerations by the amount of ground to be covered in the area common to a pair of photographs. To cover a large area economically this implies an *overlap* of just over 50%, so that we can seldom achieve much by juggling with base lengths. In peace-time topographical surveys, the airman will normally be asked to fly as high as he can reasonably climb, in order to save money by cramming

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much country into one picture. In war, the same condition will usually hold for other and more obvious reasons, and that will dispose of the question of flying height. In the majority of cases we must accordingly be satisfied with what we can get in the way of parallax differences, and attempt to make the most of them in the stereoscope. Nevertheless, if the immediate end is the examination of minute differences in relief on the ground—and this will frequently be the case in Intelligence work—the above drawbacks to these means of increasing the stereoscopic effect must be faced.

The Stereoscope.

Hold a sheet of cardboard on edge between the two dots in Fig. 2, so that one dot only is seen by each eye, the other dot being hidden by the cardboard. Place the head opposite the dots in the "square on" reading position and attempt to look *through* the paper. If anyone has difficulty in performing this feat, let him make two similar marks on a window pane and actually look beyond them to some object outside. The two dots will move inwards and will eventually come together and *fuse stereoscopically*. To anyone unaccustomed to stereoscopic observation it is quite likely that this single fused dot will appear blurred; if so, maintain the dot in fusion by an effort of will and look back at the paper, thus bringing the image into visual focus. It will also help if the dots are not placed too close to the eyes.

Fig. 2.

Next, keep the head still, concentrate on the fused dot, and twist the paper round slowly. The eyes will first experience a feeling of strain, the dot will then become blurred, and will finally go out of fusion. For easy fusion, in fact, it is necessary for the line joining the two dots to be parallel to the "eye base," that is to the line joining the centres of rotation of the eyes. It will be seen, however, that there is a considerable visual tolerance in this respect.

There should now be no difficulty in understanding the function of the simple stereoscope. Both photographs are first oriented so that the two corresponding photographic images of each object on the ground (exemplified by the two dots in Fig. 2), fall on lines parallel to the "eye-base"; the optical system of the stereoscope in effect shifts the two photographs laterally so that these corresponding points lie quite close together, at the same time ensuring that each eye sees only one picture; and the eyes complete the process by breaking down the remaining separation of these corresponding points and fusing them. The result is the appearance of a single picture in stereoscopic relief.

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We shall now consider each of these steps in greater detail.

Orientation. Return for a moment to Fig. 1. The points c, c^1 will correspond to points C, C^1 on the ground, represented, say, by a tree or some point in the middle of a field. These same trees, or what not, will be imaged on the *other* photograph of the pair (provided we have 50% or more overlap) at c_1, c_1^1. The lines $c\,c^1$ $c^1c_1^1$, on the photographs may be known as the *photographic directions of the air base.*

The mathematician may show, for his own amusement, that, whatever the relief of the ground, parallax displacements are always in this direction. In other words, if we superimpose the two photographs with the directions of the air base coinciding, any two corresponding images will lie on a line parallel to this direction. The mathematician's word may be taken for it, but we must recognise the fact.

This then is the condition which must be fulfilled in orienting the two pictures; the two directions of the air base must be made to coincide in the superimposed images formed by the stereoscope, and this common direction must moreover lie parallel to the eye-base.

Neglect of this condition is the most prolific source of trouble in stereoscopic work. At the least it entails a loss in relief where parallax differences are small. When parallax differences are larger, and a loss in relief is of less consequence, the result, as was seen in the dot game, is eye-strain, blurring, and in extreme cases a breakdown of fusion.

The usual method of orientation is the reverse process of juggling the prints until they fuse easily, and for rapid " look-see " work this is quite sufficient. If, however, the object is to appreciate relative relief over comparatively large areas, or to contour the prints, a rather more refined procedure is necessary. The " principal points " of the photographs, which for the moment may be confused with the plumb points c, c^1 of Fig. 1, will invariably be marked in pictures taken with surveying cameras. Their correspondents c_1, c_1^1, on the other photograph of the pair may be identified and marked, and the actual directions of the air base drawn in. Correct orientation will then be obtained by making these two lines coincide under examination in the stereoscope. A more rapid and accurate method will, however, be given later under the heading of parallactic grids.

It is very necessary that the two prints should be placed in the right order. First superimpose them with the common area very roughly in coincidence. Then, provided that no inversion is introduced (or more correctly no odd number of lateral inversions are introduced), by the stereoscope, the right-hand picture as thus placed must be seen by the right eye. If this order is reversed, the result will be inverted or *pseudoscopic* relief, the landscape being

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in effect, turned inside out. Not everyone will see this effect, but it is nevertheless there, and may be shown up by various artificial means. In such cases, the majority of observers will get no sensation of relief at all.

Optical Construction. If the dot game is repeated with an increased separation between the dots it will be found much more difficult to fuse them ; in fact it is only after considerable practice that a separation of more than 2 inches can be broken down without artificial aids, and in no case can this separation exceed about $2\frac{1}{3}$in. With the large prints common in air photography, however, it is seldom that corresponding points can be placed as close as this without actually placing one photograph on top of the other, and thus obscuring it, so that some optical contrivance is required to reduce the separation within fusible limits.

There are various means of achieving this end. The commonest (Fig. 3), is the Brewster type of stereoscope, in which prisms or half lenses are placed in front of the eyes. Rays of light from the photographs aa, bb are *deviated* through these prisms or lenses with the result that the pictures appear to lie at a^1a^1, b^1b^1. A slight magnification (in the case of lenses) may also be introduced in the process.

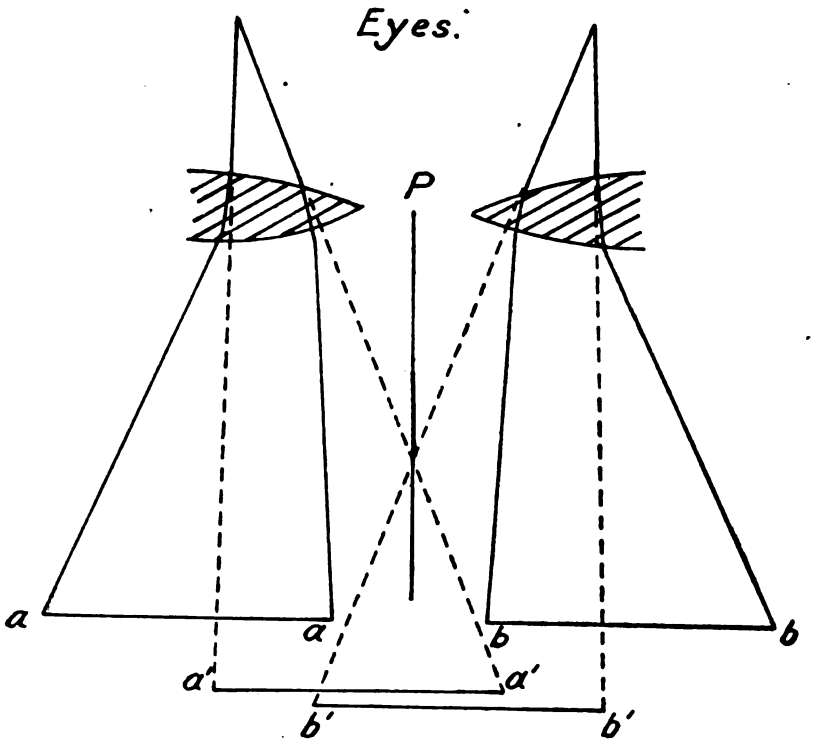

Fig. 3.

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A partition P will ensure that only one picture is seen by each eye, but if this is omitted the only result will be that satellite photographs are seen on each side of the central fused picture.

Alternatively, we may follow the original Wheatstone stereoscope and use a pair of parallel mirrors MM^1 (Fig. 4), inclined at 45° to the common plane of the photographs.

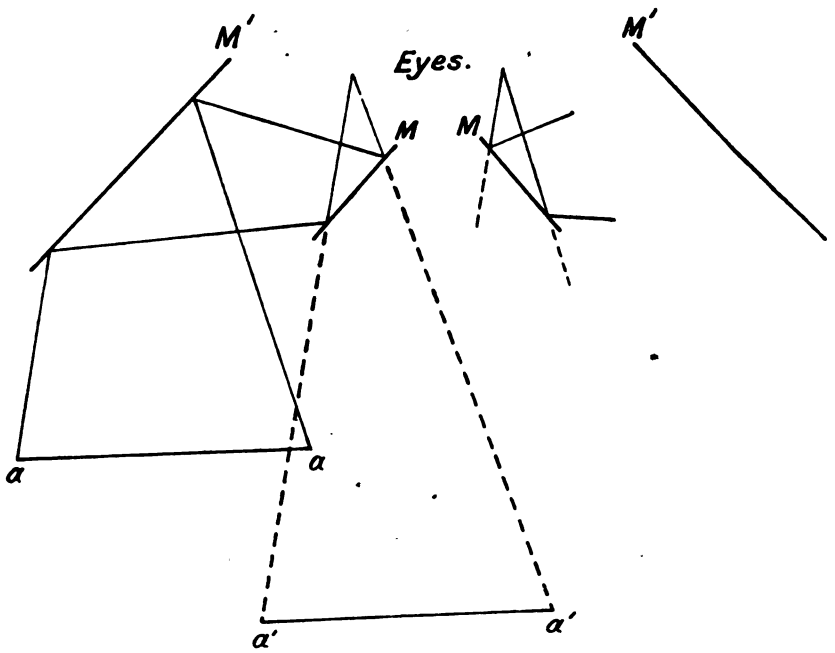

Fig. 4.

There are countless variations of these two basic types, differing mainly in name, and anyone possessing a nodding acquaintance with the laws of reflection and refraction will have no difficulty at all in understanding the magic of any particular make. Generally speaking, instruments of the first type are optically imperfect, in that they introduce various distortions which may result in eye-strain, but they possess the merit of portability. The second type are sound optically, are not always easily portable, and frequently make the mistake of forming the virtual images a^1a^1, b^1b^1 at too great a distance from the eyes. The significance of the latter drawback will appear later. These disadvantages, and others, are however largely overcome in the new Topographical Stereoscope by Barr and Stroud, a photograph of which is reproduced (Fig. 5).

This instrument is of light construction and shuts up automatically into a small hand case. The virtual images are formed at a

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fixed distance of 12ins. from the eyes, a distance which is found to be most generally suitable for topographical work

Fig. 5.

Only one other variation is described in some detail, not, however; because it introduces any modification in rock-bottom principle.

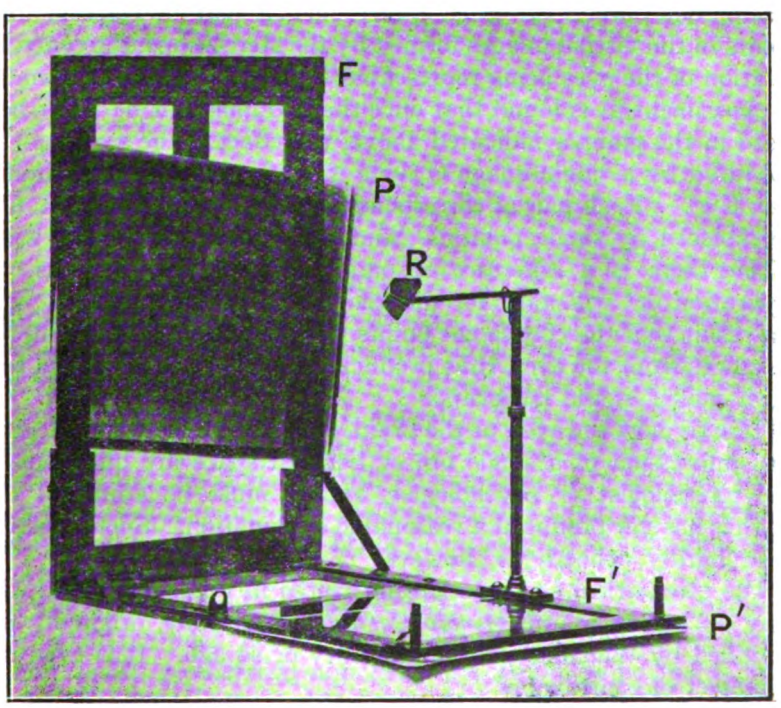

Fig. 6.

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The experimental model of this is illustrated in Fig. 6. The photographs P, P^1 are carried under spring steel strips on the frames F, F^1, which shut up like the leaves of a book when the instrument is not in use. P^1 is viewed directly with the right eye, while P is seen by the left eye through the *roof prism* R, the function of which is to deviate the image of P through 90°, so that it appears to lie in the same plane as P^1. At the same time the prism totally inverts P, so that, in setting, P must first be turned round through 180° in its own plane. For the better perception of *local* relief, the distance of the eyes from the photographs is purposely kept down to about 8ins., which is normally supposed to lie within the closest distance of distinct vision. If any trouble is experienced from this cause, the observer should wear a pair of low power convex spectacles in addition to any reading glasses he may normally use.

Visual Factors. It is clear that all the stereoscope can do is to bring the two photographs together so that certain pairs of corresponding points will coincide; from the very fact that the two photographs must be dissimilar, the stereoscope cannot possibly bring *all* pairs of corresponding points into coincidence, so that there will, in general, be small differences left for the eyes to break down.

Suppose that o, o^1 (Fig. 7) are such a pair of corresponding points in the virtual images formed by the stereoscope, the centres of rotation of the eyes being represented by E, E^1. Then, as a matter of experiment, it is found that once the two images o, o^1 have been fused in the manner indicated above, the effect is the same as that produced by a single image O lying in space at the intersection of E o, E^1o^1. Each pair of corresponding points o, o^1 could, in fact, be replaced by single points O, and we should be none the wiser. Where there is a *difference* of parallax in the photographs, the separation oo^1 will vary for different parts of the pictures, with the result that the equivalent points O will appear to lie at different distances from the eyes, thus producing the effect of an actual solid relief model of the landscape.

Exactly how the eyes, or the brain, are able to receive and register this impression of a single object lying in space are questions for the physiologist or psychologist, and it must be admitted that neither has yet produced a reasonable explanation. Such questions need hardly concern us, however.

The geometrical construction illustrated in Fig. 7 embodies what may be known as the *principle of ortho-stereoscopy*, originally propounded by Wheatstone a half century or so ago. It is even now a subject of controversy.

For instance, if o and o^1 are separated gradually while being retained in fusion, we can, after a little practice, make $o\,o^1 = EE^1$.

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The fused image should then be formed at infinity. It will, however, appear quite close. It is even possible with practice still further to separate o and o^1 when the fused image should appear "beyond infinity," that is at the back of the head—which is manifestly absurd. It has indeed been pointed out above that we have no

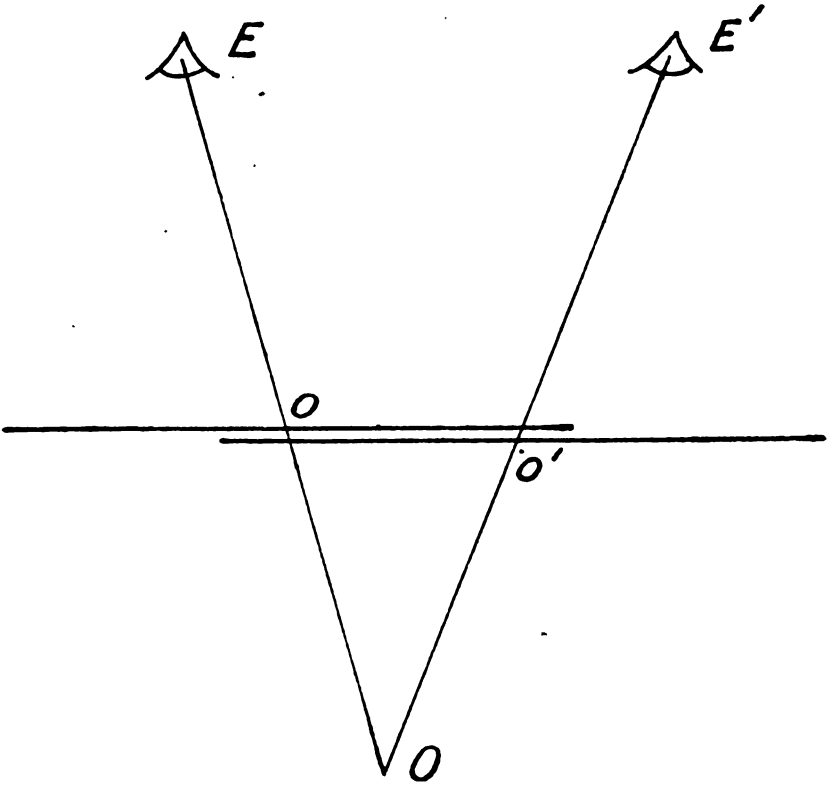

Fig. 7.

means of assessing its *absolute* distance stereoscopically, and if no relative standard is provided it may *appear* to lie anywhere, irrespective of the actual position required by a geometric theory. If however, this experiment is repeated with a fixed standard of comparison, such as is provided by the parallactic grids to be described later, no difficulty will be experienced in actually *seeing* O recede into the distance as the separation of o and o^1 is increased. In this case also, fusion will break down long before the impossible case is reached.

If the eye-base had not been placed parallel to o, o^1 it is easy to see that the lines Eo, E$^1o^1$ would be skew, so that, if we persist in our rigidly geometrical notions, there would be no fused image at all. The fact is that, although they will not stand too much of this sort of thing, the human eyes are tolerant organs and have never

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learnt geometry. The head moreover is continuously, perhaps subconsciously, shifting in order to satisfy this condition.

A further objection which has been advanced against this principle is illustrated by the dot game in Fig. 2. If this simple experiment is repeated without the cardboard screen, two satellites will be seen on either side of the fused central dot. All three dots appear to lie at the same distance. But, whereas the central dot should, according to this theory, lie in space well *below* the paper, the two outer dots are concrete objects lying actually *on* the paper. The explanation is, probably, that if we do not shift our attention from the fused dot, the two satellites are each seen with one eye only. To check this, close one eye, when one of the three dots will disappear. Consequently the satellites may lie anywhere in space for all we know, and we naturally *associate* their distance with that of the fused image under consideration.

This theory is of fundamental importance to a true appreciation of the subject, and the above somewhat long dissertation must accordingly be borne with patience. It may be assumed that it does hold generally, in so far as it may be used to predict results which bear practical fruit, and this, after all, is the acid test of any theory.

There is, however, a big physical difference between viewing a stereoscopic pair and the corresponding actual concrete relief model. If the latter, or indeed any collection of objects in nature is viewed, the eyes are automatically focussed or *accommodated* for the distance of the particular object fixed. At the same time the axes of the eyes are *converged* to an amount also depending on the same distance. These two properties of accommodation and convergence are physiologically connected, and we cannot at once vary one apart from the other without doing violence to our feelings. But in the stereoscope, accommodation is fixed by the actual apparent distance of the prints, whereas convergence must vary with the amount of relief and the general distance of the reconstructed solid image. No doubt this point was appreciated in the dot game, where the initial effort to converge for the farther distance of the fused dot carried in its wake the corresponding change in accommodation, with the result that the dots appeared blurred. There are, of course, certain visual tolerances in this respect, or we could never use a stereoscope at all, and these tolerances can moreover be very considerably increased without injury to the eyes by a little gentle practice at the dot game.

For this reason the separation of the prints, or the optical parts of the stereoscope, should be so adjusted that the reconstructed image is formed in and around the virtual images of the prints. This is usually done by pushing the prints about until they fuse nicely, or, if it is required to fix the prints, the plane of accommodation may be shifted (by trial) by using a suitable pair of spectacle lenses.

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Even then, however, the *range* in relief may necessitate excessive departures from the convergence corresponding to this plane of accommodation. This will seldom if ever happen with verticals, but it does happen with obliques, where the range in depth at exposure may be many miles. The remedy is then to remove the source of trouble by decreasing the *range* in relief of the reconstructed image, say by decreasing parallax *differences*. This may be done by varying the conditions of exposure, as we have seen, or by varying the conditions of examination, to be investigated in the next section.

The foregoing principles are very well illustrated in a recent form of variety entertainment, which may accordingly be explained as a means of "sugaring the philosophic pill."

A screen S (Fig. 8) in front of the stage is illuminated from two

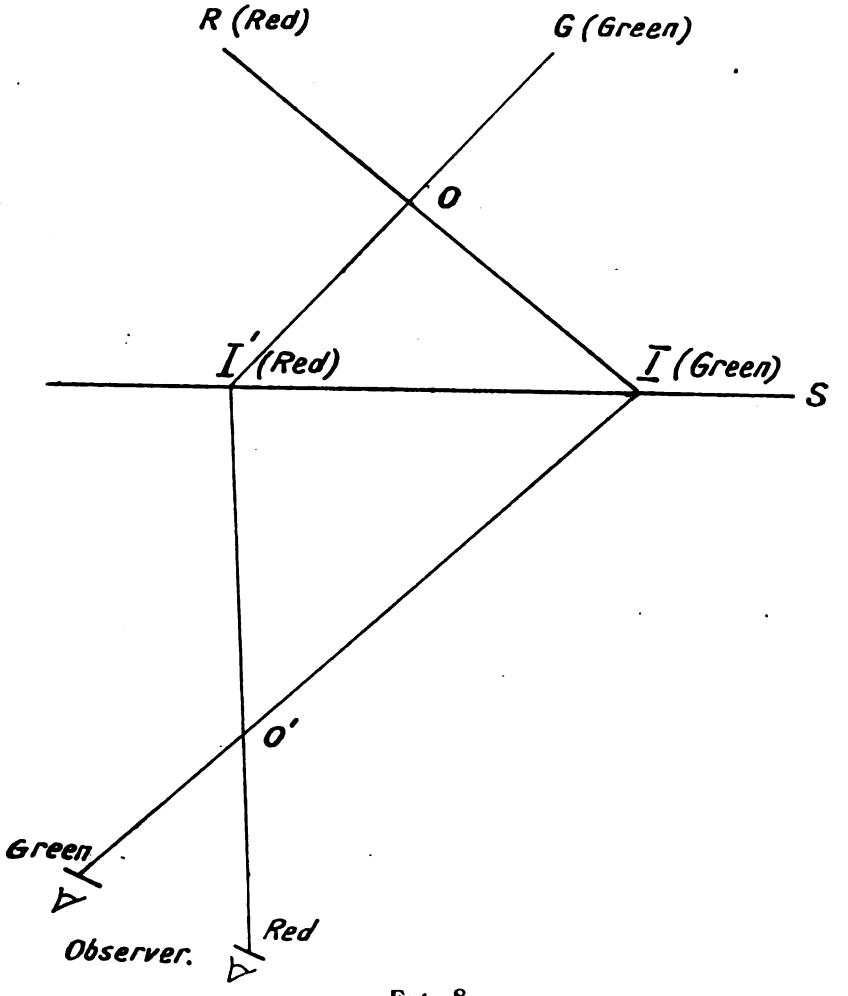

Fig. 8.

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projectors R and G with two complementary colours, say red and green. An object O situated between the screen and the projectors will consequently throw a shadow I, which is illuminated by the green source of light only, and similarly a red shadow I^1. The remainder of the screen, illuminated equally by both complementary colours, will appear white. If an observer on the other side of the screen places coloured filters before his eyes, he will see each coloured shadow through its appropriate colour filter, the other shadow being cut out completely. A stereoscopically reconstructed image is thus formed in space at O^1. As O moves towards the projectors, the separation of I and I^1 increases, with the result that O^1 appears to *move towards the observer*. O must, however, move towards the centre of the projectors in order that the two shadows may remain roughly equal in *size*. They are otherwise difficult to fuse.

If now the ladies of the chorus stand behind the screen and throw various articles towards the projectors, the audience will be under the impression that these articles are being thrown at *them*, and the illusion will be preserved by the increasing size of the shadows, and consequently of the reconstructed images, as the objects appear to come closer. The two projectors are placed at the same height above the stage, so that the two shadows are also thrown at the same height. Consequently it is merely necessary to keep the eye-base in the normal horizontal position to avoid orientation troubles. The shadows will usually move off the screen before convergence to the reconstructed object is too far divorced from accommodation for the distance of the screen, but for observers in the front row of the stalls, the shadows may remain long enough for the normal accommodation—convergence tolerance to be exceeded. In that case, and provided an imaginative audience has not by then shut its eyes, the reconstructed image will become blurred or go out of fusion.

The "anaglyph," which has recently received much publicity in the *Illustrated London News*, will be recognized as another application of the same principles.

STEREOSCOPIC RECONSTRUCTION.

It remains to apply this principle of ortho-stereoscopy to an examination of the reconstructed relief image.

Fig. 9 shows the two *virtual* images of the photographs formed by the stereoscope at a distance f^1 from the eyes E, E^1. o and o^1 are a pair of corresponding points which combine to produce a space image O, at a distance H^1 from the eyes. c, c^1 are the plumb points of Fig. 1, separated by a distance d. b^1 is the "interocular distance" EE^1.

We have already defined $oc \sim o^1c^1$ as the parallax p of the point O. If, however, the photographs are enlarged or magnified m times, the *effective* parallax will be mp. Consequently $oo^1 = (d - mp.)$

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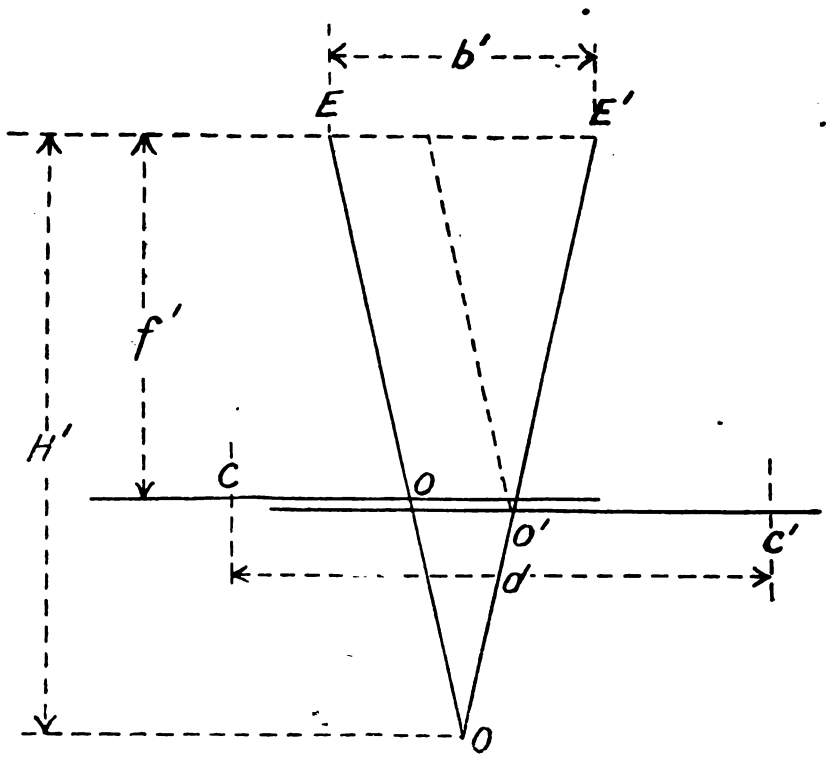

Fig. 9.

Two similar triangles in the figure then give us, as an expression for the depth of O, our second line of mathematics, and the Exodus of Stereoscopy :—

$$H^1 = \frac{b^1 f^1}{b^1 - d + mp} \qquad (2).$$

Combining this with (1) we get the third and last line

$$\frac{H^1}{H} = \frac{b^1 f^1}{b^1 - d + mp} \times \frac{p}{bf} \qquad (3).$$

Now if the space image is to be reconstructed to some uniform depth scale (the condition being that $\frac{H^1}{H}$ shall be constant for all values of p), it is apparent that d must equal b^1, or that the eyes must be placed " opposite " the virtual images of the plumb points. If this condition is not fulfilled, it may be shown, and verified by experiment, that as the prints are gradually separated so that d exceeds b^1, the bottoms of valleys sink away relative to the tops of hills, and there is a general opening out and distortion of the relief effect. And the converse holds when d is decreased. Where a

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true picture is of less importance than the appreciation of small differences in depth, this property of increased separation may consequently be used to *intensify* the general relief effect.

If, on the other hand, this condition is fulfilled, the resulting uniform depth scale will be $\frac{b^1f^1}{mbf}$. For this to be equal to the plan scale it is further necessary to make $f^1 = mf$, since if all scales of reconstruction are to be equal, they must each be equal to the ratio of any two corresponding lines, that is to $\frac{b^1}{b}$. If, however, we require an intensified relief, we may increase magnification m, or, what amounts to the same thing, decrease the distance f^1 of the virtual pictures from the eyes.

The latter remark may seem a little difficult to justify, since it will be seen that these recommendations for producing an intensified relief actually amount to flattening the depth scale. At the same time, however, they succeed in bringing the reconstructed object *closer* in the same ratio, so that, again at first sight, it would seem that apparent depths should be unchanged. The capacity of the eyes for appreciating a given difference in depth of an object varies, however, inversely as the *square* of the distance of that object, with the result that, as far as intensity of relief is concerned, we are more concerned with bringing the object closer than with reducing its actual depth in a direct ratio. The case is indeed much the same as in Fig. 1, where we have seen that halving the height of the aeroplane produces four times the difference in parallax for a given difference in heights on the ground. The eyes can in fact be considered as a pair of cameras whose axes are variable, so that they appreciate differences of parallax in exactly the same way. From the fact, however, that the axes are variable and can be directed to any point in space, it is clear that there can be no fixed origin for the appreciation of absolute parallax or absolute distance, a point which has been stressed before. The " sensitive surfaces " of the eyes are moreover curved and not flat photographic plates, so that we come to be concerned more with differences of angular parallax, that is with differences of convergence of the axes of the eyes. Without plunging further into controversial matters, it may be assumed that there is otherwise no essential difference between the two cases.

Extension to Tilted Photographs.

So far we have considered the case of two truly horizontal negatives exposed from the same height, and it is all very simple. If now the photographs were tilted at exposure out of their common

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horizontal plane, various odd perspective displacements are introduced which the surveyor terms tilt distortion. For the small tilts usually encountered in vertical photography these displacements are quite near enough radial from the plumb points c, c^1. Their resolved parts *parallel* to the direction of the air base appear as a false contribution to parallax, which must be got rid of or allowed for, if our object is the stereoscopic measurement of depth. Fortunately this can be done by various means. Conversely, if a few spot heights are known by measurement on the ground, it is possible to evaluate this false parallax and thus get at the amount of tilt present.

On the other hand, if the object is merely to see the general run of the country or to sketch contours between a close height control, there is no need to worry about small tilts. The effect is indeed a gradual, though not necessarily uniform, change in apparent depth over the whole print, which does not materially upset the stereoscopic image within a restricted area. As a maximum result, the stereoscopic appreciation or measurement of slopes in the reconstructed image may be anything in error up to the greater of the two tilts. This need rarely exceed a degree, a figure which in course of time will be still further reduced.

A similar false parallax is introduced by raising one camera station above the other. The effect in this case is for a contour plane in nature to appear tilted in the stereoscope by the angle of inclination of the air base to the horizontal. Under modern conditions of flying this may also be decreased to the order of a degree, with the prospect of still further reduction.

The resolved part of these odd displacements *at right angles* to the direction of the air base introduces a fresh trouble and a fresh term. Call it " transverse parallax," and define this a little more closely by superimposing the two photographs with the directions of the air base in coincidence. The two images of an original point on the ground will then be separated in a direction at right angles to the air base by the transverse parallax of the point considered.

We have already seen that this new bogey is likely to lead to trouble in fusion, although this seldom becomes acute for tilts under 5°. It does not upset the relative depths of objects in any way. Since it is caused entirely by exposure in different planes, it may be measured and turned to account as a means of finding *how much* one picture was out of the plane of the other at exposure. The two pictures may otherwise be set in relation to one another in one of those complex stereoscopes known as plotting machines, by juggling them about systematically until there is no transverse parallax left in the stereoscopic image. Special means of observation are, however, necessary for this purpose in order to overcome the tolerance of the eyes in this respect.

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THE USE OF PARALLACTIC GRIDS.

The perception of differences of parallax is by no means the only contributory cause of an impression of relief. In fact, the examination of a single photograph will frequently leave little doubt as to the general run of land forms, the observer then being influenced by such causes as light and shade, and, in the case of obliques, by the relative size of objects and an increasing haze effect as the country recedes into the distance. Experience and common sense also play considerable parts.

In the case of a stereoscopic pair, G.H.Q. at the brain receives information from all these sources as to relative depths, " appreciates the situation," and comes to a decision. And, if the information is unreliable or inconsistent, the decision may be a wrong one. For instance, the *direction* of parallax may be reversed by simply interchanging the prints, in which case we should get a pseudoscopic image in inverted relief. This may simply be illustrated by drawing a picture on the lines of Fig. 9. The mental department of Common Sense will often not admit the possibility of any landscape appearing in this absurd form, however, with the result that the brain compromises by asserting that the landscape is flat. On the other hand, a trained stereoscopic observer, whose appreciation of parallax perhaps outweighs his common sense, will see the effect at once, particularly if he knows what to expect.

We can hedge against such a wrong decision by taking two precautions. Firstly, the conditions of observation can be so arranged that all these subsidiary causes *combine* with the perception of parallax and are not inconsistent with it. Thus we can make the run of shadows in the photographs consistent with the lighting of the room or dug-out, and with the position of the observer. Secondly, the perception of parallax may be stiffened by providing some standard of estimation. This is simply done by placing over the photographs a pair of transparent *parallactic grids* consisting of a pattern of lines which will combine to produce a secondary stereoscopic impression.

If these grids (one of which is shown in Fig. 10) are entirely similar in form and are similarly oriented with respect to the direction of the air base, it is evident that there will be no difference of parallax between corresponding lines, so that they may be fused to convey the impression of a network lying *in a plane* in space. In the case of a pair of verticals taken from the same height, moreover, this grid plane will represent, *relative* to the photographs, a *horizontal* plane in nature. Further, the grid plane may be moved *down* in space, again *relative* to the photographs, until it appears to sit on the top of any desired natural feature, by merely increasing the separation of the two grids over the photographs. A glance at Fig. 9 will establish this point. A reference plane has thus been

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provided in the stereoscope, against which differences in depth in the landscape are readily perceptible. The result is a more vivid and a more certain impression of relief.

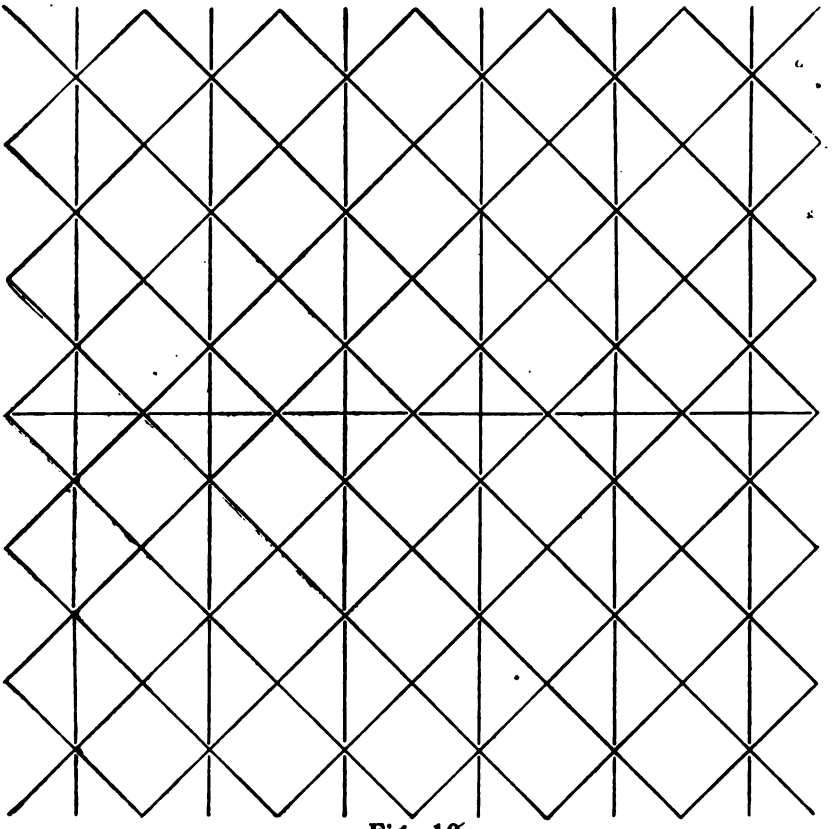

Fig. 10.

In the absence of tilt, etc., a contour could thus be traced by noting points where the grid lines run into the ground, the grid setting being calculated from equation (1). It would be possible, moreover, although not very simple, to modify the form of the grids so as to allow for tilts, and difference in height of the air stations. In the usual case of slightly tilted photographs, however, its use must be restricted to limited areas between a close control.

The grid itself furnishes a means of estimating how far it may be trusted in this connection. Suppose that a pair of grid lines fall with reference to say a tree as shown in Fig. 11, where the images of the tree are affected by transverse parallax. The lines a, a^1 are at a less separation than the images of the tree, with the result that they fuse to form an image lying above the tree. Similarly b, b^1 form an image lying below the tree, and the effect is of two lines crossing in space at different depths. Taken as a whole, the two crossing lines should lie in the same plane, since there is no difference of

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parallax between them, but at risk of repetition, it must again be emphasised that any phenomenon connected with stereoscopy is

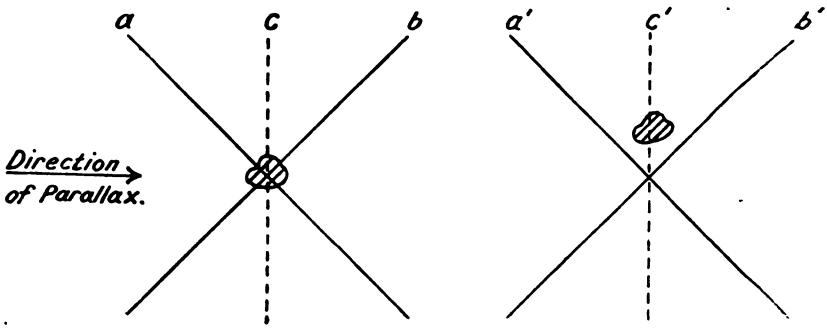

Fig. 11.

purely a *relative* affair. In this case the two crosses have a weak stereoscopic character in comparison with the photographs, and have been chosen in this form for this very reason. The result is that they offer little resistance to being broken up under the stronger influence of the photographs. Indeed, if this stronger influence is removed, by raising the grid plane well above the ground, the two crossing lines will begin to re-assert themselves and will return to the same plane, so that to perceive this effect it is necessary to run the grid down on to the ground. The effect may be removed altogether by adding a third line c,c^1 possessing a very strong stereoscopic character. The composite cross will then appear in space at a depth required by the interaction of the photographs and the lines c,c^1, whatever the weaker minded diagonal lines have to say about it.

This question of the relative stereoscopic character of the photographs and an artificial "floating mark," such as the grid lines discussed above, is of considerable importance in stereoscopic measurement, although it has so far received little attention. The photographs derive their stereoscopic character entirely from the combination of corresponding detail; the more distinctive and clearly defined is this detail, and the greater the amount of such detail included in the field of view, the better will be the resulting stereoscopic character. This property is quite distinct from the intensity of relief derived from difference of parallax; the former is, for instance, decreased by magnification, while the latter is increased. The character of the marks on the other hand depends on their arrangement relative to the direction of convergence, and on the existence of parallax differences producing a solid mark, such as a cone or pyramid, in addition to such factors as size and density. A mark possessing too strong a stereoscopic character is very apt to overpower the photographic impression, and to produce blurring and uncertainty in observation. This is indeed only common sense;

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we could no more compare two notes in music if one completely drowned the other.

By this means it is possible to transform transverse parallax, which is difficult to perceive, into twice the amount of sensitive stereoscopic parallax difference. Measurement of transverse parallax for various purposes thus reduces to the ordinary case of determining stereoscopic parallax. Look for transverse parallax in the corners of the overlap. If there is none, or very little, over the whole area, the photographs were exposed in the same plane. In the absence of constant tilts, and special means should always be taken to avoid these in survey flights, the odds are that this common plane was horizontal, in which case the grid may be trusted in contouring over greater uncontrolled areas.

Now whatever the (small) tilts, or difference in height of the air stations, transverse parallax is never introduced along the direction of the air base. Exactly the same effect is, however, introduced by wrong orientation. Consequently this property of the grids may be used to secure correct orientation by rotating each photo in turn until the effect disappears in the region of the plumb point of the other picture. The directions of the air-base, which are required in most simple methods of plotting, may then be scribed on the photographs.

In the new Topographical Stereoscope, the grids are made by etching fine grey lines on glass plates. One of them is provided with a slow motion lever, and the carrier frame of either may be swung away from the photograph in order to sketch contours on the prints.

Anyone who has waded through the above will have no difficulty in using a stereoscopic pair intelligently, and in getting the very best out of the photographic material, whether for survey work or for the less exacting requirements of Intelligence. He will, moreover, be equipped with a sound knowledge of general principles which will enable him to grasp the inner workings of the more complex stereoscopic plotting machine ; but it still remains for him to acquire stereoscopic facility by practice. No amount of reading will supply this.

Practice at the dot game, with a gradually increasing separation of the two dots, will prove beneficial to one's powers of fusion, and will also increase stereoscopic acuity. It should, however, be attempted gradually if eye-strain and severe headaches are to be avoided. Apart from this artificial means, there is no better practice than that conveyed by *using both eyes* all day and every day, and using them in the conscious estimation of relative distances.

Stereoscopic observation, with a suitable stereoscope used intelligently, need never be painful. It can, indeed, become a pleasure, and will improve, rather than impair, the eyesight of the observer.

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ILEX IN THE OCEAN RACE.

By ONE OF THE CREW.

(Reprinted from *The Yachting World & Marine Motor Journal* of October 23, 1926).

It was at a Cowes strangely quiet after its recent activities that *Ilex* arrived on the evening of Friday, 13th (! ! !) of August. As in the case of *Fulmar* last year, she had been in Messrs. Camper and Nicholson's yard for final tuning up, the chief item being the removal of the propeller and as much of the propeller shaft bracket as could be detached. *Primrose IV.*, which came in second, had, like *Ilex*, a feathering propeller, but it was not removed for the race. Is it too much to suggest that our narrow margin of thirteen minutes might have been on the debit and not on the credit side of the account but for the removal of that propeller and bracket ?

The Ocean Racing Club is indeed becoming a club in more than name now. Last year being the first year of the Fastnet Race, the crews of the various yachts were strangers ; this year, on the Friday night in the Royal London Club House there was a great gathering of the clans among those engaged in last year's struggle—last year's crews of *Gull*, *Banba*, *Saladin*, *Fulmar* and *Jolie Brise* were all represented.

We, in *Ilex*, of course, had to go aboard the American schooner, the crew of which welcomed us none the less heartily because we were the tail end of an enormous procession of sightseers to that craft. Those Americans must have heaved a sigh of relief when the start was made: how they got stowed at all with such a stream of visitors is a mystery. A dinner ashore with them afterwards made us all hope sincerely that we should see them again in next year's race.

Comparing this year and last, I do not think that we improved much on our arrangements in *Fulmar*, Remembering our fear of water shortage last year, we took on board a vast supply of liquid, and food for ten days. The food, as before, was mainly tinned, but we took more fresh fruit and vegetables, including a gift of a sack of onions from *Primrose*, and also a barrel of salt beef which was placed in the dinghy and unearthed untouched at the end of the race from beneath a huge pile of wet clothes.

As to the size of the crew, it was decided to increase the numbers on last year, and thereby we possibly fell into a trap. We were distinctly overmanned, carrying, as we did, one yacht hand for below-

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deck duties and nine amateurs. This large number necessitated keeping watch and watch, as two watches could not be accommodated below together. If we had carried seven amateurs and the paid hand, we could have kept three watches, only keeping watch and watch during hard weather. The crew of nine did, however, enable the maximum numbers of the Corps to get the experience of the race.

It is a little difficult to know where to start this chronicle. Perhaps it ought to start at the moment when the crew began falling overboard. If that is the case, this chronicle starts at 5 p. m. on Friday, 13th, as *Ilex* was stowing on arrival at Cowes, when a good round ocean-racing oath, a splash, and a roar of joy indicated that the ship's Hercules had disappeared over the side with the broken end of a tyer: it might well have ended early on Saturday morning while watering alongside the pier, when a pleasure steamer insisted on passing at full speed quite close to us, the sportsman on the bridge acknowledging our request for him to slow down with a breezy wave of the hand. Nevertheless, in spite of all such misadventures, 10 a.m. saw *Ilex* cruising about the starting line with all shipshape on deck and everyone anxious to be off: not quite shipshape below, as the sound of thumbs being hammered in the bowels of the ship was indicative of the repair by the skipper of a leaky inspection cover to one of the water tanks, which repair was completed in plenty of time for the start. It is curious that for the second year in succession the R.E.Y.C. have been faced just before the start with a defect in the water supply system, and luckily on both occasions it has been spotted in time.

11.30 a.m. saw us cross the line, and the second ocean race had started in bright sunshine and with a light westerly breeze giving us a run to the forts. The start was of the usual ocean racing type, with each ship concentrating on being studiously polite and avoiding risk of protest rather than endeavouring to make a real racing start. The yachts almost immediately started to sort themselves out into their handicap order. *Hallowe'en*, a swan among ducks, at once opening out a lead, followed by *Jolie Brise*, *Ilex*, *Gull* and *Saladin* in a bunch, with *Primrose*, *Altair*, *Penboch* and *Banba* further astern. All eyes in *Ilex* were on the American: the result of an ocean race is almost impossible to prophesy, but we had come to the conclusion that given light airs we should be hard put to it to save our time on *Hallowe'en* and that given strong, especially reaching winds, *Primrose* was our chief danger. Given a mixture of both and *Hallowe'en* again seemed indicated as the chief opposition.

The wind to the forts was very patchy, second place changing hands more than once. On altering course past the forts, *Hallowe'en* led, with *Jolie Brise*, *Saladin* and *Ilex* in close company and *Gull* a little astern. The remainder of the fleet had dropped behind. The spinnaker was now taken in and the reaching foresail set, and a good

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meal of steak and onions was rapidly disposed of—the last good meal that some of the crew were to dispose of for some time. By 1.25 p.m. we were past Bembridge Ledge, close-hauled on the starboard tack, with *Saladin* deposed from third place and with every hope of deposing *Jolie Brise* from second place in the near future. The wind had freshened considerably and the mizzen was taken in as, close-hauled, it was a hindrance rather than a help. It would probably have been advisable to take down the jackyarder as well, as it was doing little or no work. We contented ourselves instead with re-setting it, and hung on to it for another three hours. At times we ran into quite an uncomfortable lop : several members of our boisterous crew were getting a little less boisterous, strange hues were visible on their countenances, and they unostentatiously took up positions whence they had a clear run to leeward ; every now and then . . . but 'nuff said. Except to mention that apparently the crew of *Ilex* were not alone in suffering from *mal de mer* that day. About 2 p.m. *Gull* made a leg inshore, followed shortly afterwards by *Saladin* and later by *Jolie Brise*. We did not consider this step advisable and stood out after *Hallowe'en* until 4.15 p.m., when we went about to catch the fair tide off St. Catherine's. At 5.15 p.m. we at last took down our jackyarder, and 6.30 found us off the Needles, with *Jolie Brise* well ahead inshore and *Gull* astern well to leeward, indicating that whilst *Gull* and *Saladin* went inshore for the tide rather too soon, *Ilex* had left it a bit too late. *Hallowe'en* was already almost out of sight.

The wind now started to moderate, and jibheader, jib topsail and mizzen were set. At 10 p.m. Anvil Head was bearing north, distance about six miles. *Jolie Brise* was in sight about five miles west, and *Primrose*, sailing remarkably well on a wind, was about two miles south—not a healthy omen for us, as the schooner was supposed to be slow to windward. What was she going to do on a reach ?

The positions of our neighbours have been given in fair detail of this, the first, day of the race. From the evening of the 14th we had no neighbours and saw no sign of our opponents until we saw three of them on our way back from the Fastnet. Even at the Fastnet we could only get information as to the position of *Hallowe'en*, so that over almost the entire course we were racing in the dark against time. It is a peculiar sensation, perhaps best analogous to rowing races on narrow waters where the rival crews race against the clock. There is at times a sense of unreality about it all, a feeling that one is indulging in a very pleasant cruise, that the old ship is going very nicely as she is, why bother, say, about crawling out into the certain ducking on the bowsprit end to change the jib topsail ? It is during these spells of solitary sailing that the ocean race may well be won or lost. Then a sail is sighted, or news of one's rivals is obtained at the Fastnet, and that racing feeling returns.

Revenons à nos moutons. At 10.15 p.m. on the 14th we hove the log

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and set a course S.W. in very light airs which prevailed all night. At 6.35 a.m. our log registered only 11 miles. Our position was estimated from Portland Bill and Anvil Head, and we held our course off shore. Not a yacht was in sight. Were we first or last? Much guesswork did not solve the problem to our satisfaction. About this time the wind began to freshen again. At 8.15 a.m. we altered course W. with wind moderate from the S.W. At 8.30 we altered course to W. by N., with the ship nicely full and bye, and at 9.40 we altered course once more to W. From 8.15 a.m. to noon on the 15th we were logging a very steady six knots and a bit. At noon a sight was taken. This was the opportunity for which the writer had been waiting. Remembering previous efforts in *Fulmar* to check dead reckoning, he was waiting, pencil poised and notebook in hand, to write some comic sarcastic stuff to relieve the painful technicality of the ship's log. Not a bit of it.—— No one sat on the sextant: no one got tied up in the log book lozenges. Our navigator retired below with the data, and after hectic calculations, punctuated by a dash up the companion to the lee scuppers to ventilate Nature's grievance at having to fool round with mathematics in a choppy sea, triumphantly produced our exact position according to dead reckoning. It looked a bit fishy, but as all our sights throughout the race panned out equally well one can but bow before the marvels of science.

After midday our speed dropped to a fraction under six knots. The Start was sighted through a land mist abeam at 5.55 p.m., and 10.25 p.m. saw the Eddystone abeam about six miles distant. On the night of the 15th-16th the breeze held, and we ran into a certain amount of shipping, of which more anon. At 5.30 a.m. the Lizard Light bore N. about two miles, and course was set N.W. by W.½W. for the Runnelstone, which we passed at 8.10 a.m., having done the passage from the Start in better time by twelve hours than *Fulmar* took last year. Course N.W.½W. was held to 2 p.m., when it was altered to N.W., and the reaching staysail set. With the aid of a fine sailing breeze, *Ilex* was now logging over seven knots very steadily indeed, and all went merrily until 5 p.m., when the reaching staysail shipped a bit more water than it could stand and gave up ocean racing, the working staysail taking its place. Unfortunately the reaching staysail was too badly damaged for any temporary repairs. In the early hours of the 17th the wind began to lighten, and at 4 a.m. the Fastnet light showed up dead on the bowsprit end. The Yankee jib was set at 6 am., and at 8.30 a.m. we completed our outward journey by rounding the Fastnet, having logged 172 miles in 24 hours 20 minutes.

Last year, when rounding in *Fulmar*, we had plenty of leisure to indulge in celebrations and signalling backchat with the lighthouse. This year our communications were perforce brief. We made our race signal and code number and asked for news of the other yachts.

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The reply we got was that *Hallowe'en* had passed, and when almost out of range we made out what we thought stood for 12 midnight. With that we had to be content, but the news that we were well inside our time on the scratch boat came as a cheerful fillip. As last year, we set our course S.E. for home with all sail set and the glass falling slowly. Wind S. to S.W. freshening.

At 10.30 a.m. we passed one of our opponents, the first we had seen since the 14th. The stranger proved to be *Jolie Brise*, and passed about three miles S.W. Barring accidents, we were evidently safe from a repetition of our last year's beating from her. Shortly after, we passed about five miles N.E. of a yacht we took to be *Gull*. Here again we appeared to have time in hand. We were indeed sorry to hear of her ill-fortune on our arrival at Plymouth. At 2.20 p.m. we passed the American, outward bound and moving like a train. We had about saved our time on her, but could we hold on to it? If it lay in our power to prevent it, the Fastnet Cup wasn't crossing the Atlantic to join the great majority. The wind was backing slightly and freshening, freeing her sheets and making us harden in ours. As things turned out on the homeward journey, we made about three minutes on her. What a grand struggle homewards we should have had if we had rounded the Fastnet together!

We were racing again now all right, with no cruising inertia left. During the afternoon the wind freshened hourly, with some heavy rain squalls passing overhead. At 8.30 p.m. sail was reduced to full main and jib, the jackyarder having been taken down during the afternoon. There was the devil in that jackyarder; I am quite convinced that it was only the firm statement by our topmast hand that if he had to stay aloft much longer he was going to be sick regardless of consequences that spurred on the crew on deck to get it down at all.

When darkness fell both wind and sea were rising and soaking rain came down in the squalls. Nevertheless, though being driven hard, *Ilex* was behaving magnificently. By 10.30 p.m. she had all she wanted and was bumping rather heavily at times.

The wind becoming very strong, certainly gale force in the gusts, it was decided that she would move faster with a couple of reefs in the main. Accordingly she was hove to at 11.30 p.m., and, like maggots from a cheese, the members of the R.E.Y.C. emerged on deck to reef. Reefing on a pitch dark night in a gale of wind is an exhilarating experience, certainly a rather novel one, which in the normal way, one does not lay oneself open to. Coming from the warmth below into a solid sheet of rain and spray, with the shrill whine of a very high wind in the rigging and the welter of the sea with phosphorescent breaking wavetops all round, was like coming into another world. Although the night was pitch dark, there was no need for light. All

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that was necessary was supplied by the extraordinary phosphorescence of the breaking water.

The reefing proceeded according to plan until nearly completed, when a sudden lurch and wave sent overboard a hand who was aft on the counter. The ship being stationary, he had no difficulty in hanging on to the rail. The skipper, who was at the tiller, saw his predicament, made a dive to haul him out, and slipped over the side as well. Momentarily *sans* helmsman, *Ilex* joined in the fun and stayed. The act of staying increased the midnight bathing party to three, a little variety being added by number three keeping a hold on the main sheet instead of the rail. Much refreshed the trio clambered aboard again quite easily, and the matter of staying the ship once more was attended to. The inadvertent staying nearly cost us our topmast and mizzen, as it put the boom foul of the preventer and jumper stays. Fortunately the main sheet was hard in, thus preventing any damage.

So much journalese has already been written about our man overboard misadventures that it seems unnecessary to add to it, and impossible to improve upon it.

What a wonderful novelist the average newspaper man would make. It is so easy to picture the scene as the sub-editor, or whoever it is, sits looking at a telegram from Plymouth. " Ocean Race. *Ilex* arrived. Frightful storm. Man overboard, rescued." A bell is pressed. Enter junior news manufacturer, thirsting for glory, who is bidden to write a paragraph on this man overboard biz and to put plenty of pep into it. For result *vide* several papers of August 19 : " Yacht racing home through raging seas. . . . One of the crew washed overboard but luckily grasps end of main sheet . . . . hung grimly on while anxious comrades hauled him in," etc., etc. To be painfully truthful none of the "anxious comrades" knew anything about the incident until it was casually mentioned over a tot of rum by one of the victims some half an hour later.

At 12.45 a.m. reefing was completed and the ship once more stood on her course, S.E. by S., with wind S.S.W. and of unabated strength. Under the reduced canvas the ship was undoubtedly sailing faster than before, and riding the seas delightfully easily. We were now entering a steamer track, and sighted one or two vessels crossing our path. The job of lookout forward with the heavy rain and sea and resultant poor visibility, was not an easy or a pleasant one, but all things come to an end, and at 3.15 the wind suddenly dropped, springing up again some ten minutes later from the S.W. and much moderated. The task of getting more canvas on the ship then began. Four a.m. saw the staysail set once more. By 5.30 the reefs were shaken out, followed immediately by the setting of the mizzen and jib header. From dawn of the 18th to the finish we enjoyed a pleasant sailing breeze and bright sunshine, with a rapidly moderating sea. Every now and then came moments of anxiety that the breeze would

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die away, but, thank goodness, it did not actually fail us. We made our landfall at 8.30 a.m., Land's End showing up four points off the port bow. The Wolf Rock was spotted on the starboard bow a quarter of an hour later. At 9.10 a.m. the Yankee jib was set, with the Longships abeam. The Runnelstone was passed at 10.10 a.m., and a course was laid for the Lizard, with spinnaker set to starboard. A peaceful run, spent chiefly in drying clothes, took us to within sight of the Eddystone, when we gybed ship to fetch Plymouth. At 9.5 p.m. we passed the breakwater, making our racing signal and burning a flare, and very nearly the main sheet as well. Our flare consisted of a lump of petrol-soaked waste in a tin holder. This weapon was ignited and waved vigorously by our yacht hand—just a shade too vigorously, unfortunately, as the blazing waste flew out of the container and possibly inspired by our man overboard adventures, wrapped itself round the main sheet. Nine pair of lungs shouted different advice to the hand, who grasped the falls of the sheet and shook them vigorously, thereby securely entangling the waste in the sheet. The blaze, to our relief, burnt itself out without harming the sheet, which was too soaked with water to ignite.

We rounded Drake's Island and crossed the finishing line at 9.22 p.m. (treating our flare on this occasion as such a lethal weapon should be treated) and came to moorings under the lee of the Island rather weary and quite ready for a square meal on solid ground. Our thanks are due to the King's Harbour Master and the naval authorities for helping us in every possible way on our arrival. We were especially grateful for being relieved of a mountain of wet clothes, which were taken ashore and dried for us. Ocean racing is worth while, if only for the sake of enjoying the great hospitality of all concerned at Plymouth.

To conclude with a few general impressions of the race. From the point of view of the leading yachts, at any rate, with the exception of the night of light airs on the 14th-15th, and a short blow on the night of the 17th-18th, conditions were almost ideal for a fast passage, and it should be a long time before *Hallowe'en's* splendid time for the race is beaten. As compared with last year, those of us who spent five days in *Fulmar* continually shifting canvas in light airs are, I think, agreed that this year's race was much less strenuous. It must, of course, be realised that both this year and last we were fortunate enough to have left the Fastnet well astern before the wind freshened. During the short blow on the night of the 17th-18th, the wind was certainly somewhat stronger than anything encountered last year, but at no time did we encounter anything like the tumble of seas we ran into off the Longships in *Fulmar*. The yacht behaved splendidly throughout, and nothing more serious than broken wave tops and spray ever came aboard, although at one time she was being pressed fairly hard. All gear stood up to the strain without failure, although

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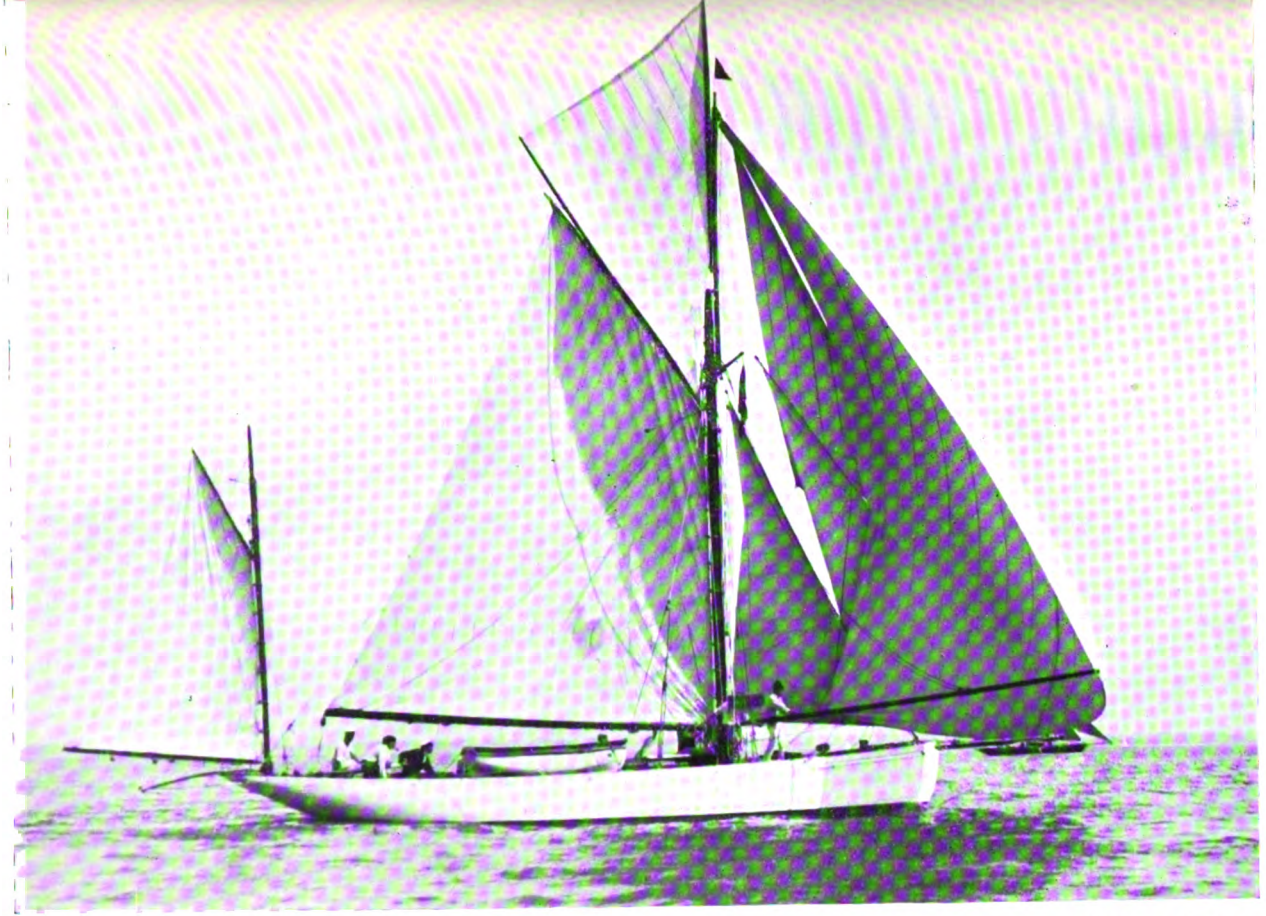

"ILEX." *Photo. by Kirk, Cowes.*

Crew:—N. A. Blandford-Newson (*Skipper*), J. H. D. Bennett, W. M. Blagden, H. A. Macdonald, P. L. Wilkinson, Capt. J. J. Carter, Capt. R. M. H. Lewis, G. N. Russell, D. N. B. Hunt and Mr. Carter (*Deckhand*).

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on getting the jackyarder down on the 17th we found the wire halliard fretted half through at the masthead. As a result we had to be content with the jibheader on the 18th (vide *Gull's* log last year). Our main difficulty was in the fo'c'sle, when all praise is due to our hand. Practically throughout the race we were sailing on the wind with sufficient water coming aboard to necessitate keeping the fo'c'sle hatch shut, and with the ship down to the rail in a choppy sea. During those four days he coped with the washing up (in salt water) for ten people, and also did a large share of the cooking; in spite of which he found time to scrub out his fo'c'sle daily. After the first couple of days a hand was detached from one of the watches to help with the cooking. Breakfast was always a hot meal, usually porridge, bacon and eggs and tea, but the remaining meals were mainly cold, usually sandwiches and tinned fruit, etc., with hot soup for supper. We were a bit chary of soup after the first evening, when our cook dished us up tomato "soup," which turned out to be made of tomato ketchup. That put the finishing touches to at least two members of the crew, who up till then had staved off seasickness, and were rather cock-a-hoop about it. A supply of Bovril served out only to the more chronic seasick victims proved a great boon. Altogether under the trying culinary conditions we fed remarkably well.

With the best will in the world, and the most careful preparations, small items may be overlooked in preparing for or during a race of this sort. Therefore this tale will be concluded with an account of how on two occasions in the race our lights gave us a trying moment or so.

The first occurred in the early hours of the morning on the night of the 15th-16th, off the Lizard, when encountering considerable traffic. We were approaching a small coastal steamer about three or four hundred yards off our starboard bow. In the normal way we should have passed green to green about two hundred yards apart. At this moment our oil binnacle lamps decided to go out, and momentarily we yawed, showing both our lights to the steamer. Thinking we were bearing away across her bows the steamer got the fright of her life, and put her helm hard over, showing her red across our bows far too close to be pleasant. A court of inquiry on the failure of our binnacle lamps demonstrated that the containers were rather too small to last out the night with any certainty, unless filled to the brim.

The second incident occurred during the blow after reefing down on the night of the 17th-18th. Once already our navigation lights had been doused by seas. We were in the steamer track with a steamer approaching on our starboard beam. In the sea then running we were of course, only visible on the top of the swell, and it was impossible to tell whether the approaching vessel was a large one fairly far off or a small one close at hand. At this point our lookout forward again reported that our navigation lights had gone out. To unship

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and light the lights and to get them shipped again was a task which under the prevailing conditions would have taken ten minutes at least, and it appeared imperative to show a light of some sort at once. The riding light, which was burning below in anticipation of such a situation, was called for, and due to improper adjustment at once blew out. It was relit and handed up, and this time it was doused as an extra heavy lurch of the ship took lamp and bearer into the scuppers. Our two electric torches were produced from the cockpit, but were soaked with sea water and out of action. By this time it was clear that the course of the approaching vessel would take her well clear of us, and our navigation lights were reshipped at leisure, but it was a lesson that the writer for one has taken to heart.

It is greatly to be hoped that some Americans will next year again attempt to lift the Fastnet Cup, and bring their trade winds and Malabars, about which we have heard so much, with them. Their presence would give a great fillip to the Fastnet race, and while possibly the great Alden racers might be able to account for any of this year's British entrants, it should also induce other and faster yachts from this side (there are plenty of them) to enter, in order to meet the challenge. Let them all come over and fight it out amongst themselves—for second prize.

SUMMARY OF THE RACE.

Boat.	Date.	Finishing Time.	Handicap.	Corrected Time.
Ilex	August 18	21 21 22	18 6 30	3 14 52
Primrose IV	,, 19	7 48 30	28 20 30	3 28 0
Halloween	,, 18	9 5 30	—	9 5 30
Saladin	,, 19	9 57 50	23 24 15	10 33 35
Jolie Brise	,, 19	4 4 19	14 22 30	12 41 49
Banba IV	,, 20	2 32 2	33 29 0	17 3 2
Penboch	,, 20	8 7 39	38 16 0	17 51 39
Gull	—	—	23 24 15	—
Altair	—	—	37 24 45	—

TIMES OF ROUNDING THE FASTNET.

Boat.	Date.	Time.
Halloween	August 17	1 0 0
Ilex	,, 17	8 0 0
Jolie Brise	,, 17	10 30 0
Gull	,, 17	14 15 0
Saladin	,, 17	18 15 0
Primrose IV	,, 17	18 30 0
Banba IV	,, 18	12 30 0
Penboch..	,, 18	13 20 0
Altair	—	—

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MEMOIR.

MAJOR GENERAL BERESFORD LOVETT, C.B., C.S.I.

Beresford Lovett was born in Paris in February, 1839, the son of the Revd. Robert Lovett, Chaplain of the Marboeuf Chapel, and afterwards Rector of Pickwell in Leicestershire. Young Lovett lived and was educated in Paris until 1850, when he was sent to a private school kept by Dr. John Jardine, at first at Turnham Green, and later at Brighton. Here he was educated until, in 1856, he was given a nomination for the Hon. East India Company's Military College at Addiscombe. On passing out after two years at the College, he was placed 8th in the final examination, obtained prizes for French, Fortification and Survey, and a Commission in the Royal Engineers. After two years at Chatham, where his chief recreation was yachting, he left in 1860 for India, via the Cape, in a sailing ship of 1,300 tons. At that time officers had themselves to pay for their passages to India, and the fare via the Cape was £70 against £120 via Egypt. The voyage to India took 84 days, and on arrival Lovett was posted to the Bengal Sappers at Roorkee, and joined there in October, 1860. After five months at Roorkee, he was posted to the P.W.D. at Ambala, and was employed on bridging on the Ambala—Kalka road and other works; and later, in 1862, he was transferred to Ferozepore, where the arsenal was being fortified in view of possible attack by Russia. From Ferozepore Lovett was moved six months later to the Frontier at Kohat, as Assistant Engineer under Major (afterwards General Sir James) Browne. In those days the Kohat P.W.D. Division extended from Peshawar to beyond Dera Ismail Khan, and here Lovett served for four years, during which he carried out much bridging and road-work, as well as training works on the Indus at Dera Ismail Khan. He must have done his work well, for in this period he more than once received the thanks of Government. It was on the Frontier that Lieut. Lovett studied Persian, a language in which he attained considerable proficiency; and in 1866 he was transferred to Persia for work on Telegraphs under Major (afterwards Col. Sir Oliver) St. John. Persia was a country that always attracted him, and his journeys on Telegraph duty between Bushire, Shiraz, Ispahan and Teheran; and to and from England on short leave, via Resht, Baku, Astrakan, Petrograd and Berlin appealed to his adventurous spirit.

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After four years of Telegraph work he was attached, in 1870, to General Goldsmid's Mission to settle the frontier between Afghanistan and Persia in Seistan and between Persia and Baluchistan from Seistan to the sea. The responsibility for the maps and surveys required by the Mission devolved on Captain Lovett; the work occupied some two years, and for his share he was awarded the C.S.I. On its conclusion, in 1872, he proceeded to England for his first period of long leave, travelling home via Baku, Tiflis, Constantinople and Athens. He arrived home about the time of the Shah of Persia's visit to London, and from his knowledge of the language was placed on duty with the Shah's uncle. He returned to India, for the first time by the Suez Canal, in 1875, and was posted as Executive Engineer at Abbottabad, where he had charge of various works scattered from the borders of Kashmir to the Khyber Pass; and of the Grand Trunk Road, including the bridge of boats at Attock. This bridge was swept away by a sudden flood in the autumn of 1878, when the expedition against the Jowakis was moving north, and Lovett's energy in replacing it led to his employment with the expedition under General Sir John Ross. The following year he was again on active service, being appointed Brigade Major R.E. with General Sir Sam Browne's Force in the Second Afghan War; and his services were rewarded with a Brevet Lieut. Colonelcy. On the conclusion of the war he went home on leave, and was then appointed British Consul at Astrabad. While here he was much interested in the oil wells at Baku and wrote letters to the *Times* calling attention to the progress which Russia was making in acquiring them.

In 1883 he was appointed Superintending Engineer at Calcutta, and three years later was transferred to the Military Works Department at Rawal Pindi. In 1888 he was on active service as Chief Engineer with the Hazara Field Force under Sir John McQueen, and was mentioned in despatches and rewarded with the C.B. In 1890 he was transferred to Madras, as Chief Engineer. He was promoted Major General in 1892, and retired two years later.

But General Lovett was far too vigorous a personality in mind and body to allow himself to rest unoccupied. He returned to India in 1897 and interested himself in investigating schemes for generating electricity by water power. He formulated, and worked out in considerable detail, a project for utilizing the water of the Nauti Khud to supply power for the water supply and electric light of Simla; a scheme which, though rejected at the time, has since been largely adopted. He also originated a project to provide 13,000 h.p. on the Jumna in the United Provinces. For this he obtained a favourable concession from Government, and was engaged in further negotiations for the work when the outbreak of war prevented its development.

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Major-General Beresford Lovett, C.B., C.S.I., late R.E.

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Until the commencement of his final illness in 1925, he maintained an active interest in all scientific matters, attending, and speaking, at lectures of the Royal Geographical Society, the Royal Society of Arts, the Persian Society, etc., and studying higher mathematics with a professor in London. He cared little for games or sport of any kind, occupying himself almost exclusively with his work, with scientific studies, and with languages. The latest piece of work he perfected (in 1925), was the construction of a Fahrenheit thermometer, with an extra scale from 32 as zero, so that the temperature above or below freezing point can be read at a glance without subtraction.

Lovett had considerable artistic talent, and some of his drawings, notably those contributed during the Afghan War to *The Graphic*, were published by that and other English illustrated papers. He was also fond of singing and had a true and delightful tenor voice. He had a wonderful memory, and his mind was a storehouse of interesting facts and events. He remembered Paris in the days when the Queen of Cities was illuminated by "reverbères," oil lamps suspended by chains across the streets, he also had clear memories of the Revolution in 1848. When he was thirteen he was taken to see the funeral procession of the Duke of Wellington, an occasion which he never forgot. During the early days in Paris, his father being Chaplain to the Embassy, the family was brought into contact with numbers of interesting people—not the least of whom was his godmother, Lady Harriet Cooper, wife of Mr. Cooper, the owner of Sandringham, (from whom it was bought by King Edward VII, when Prince of Wales). Lady Harriet's first husband had been the famous Comte d'Orsay, one of whose snuff-boxes was given to her godson.

Lovett was a man of most kindly disposition, ever ready to help those in need, cheery and optimistic, given to hospitality; and he had a wide circle of friends both at home and in India.

He married, in 1876, Agnes, daughter of Mr. W. Turnbull Blewitt. She died in 1914.

BOOKS.

WORK OF THE R.E. IN THE EUROPEAN WAR, 1914-19. MISCELLANEOUS.
Compiled by COLONEL G. H. ADDISON, C.M.G., D.S.O., M.A., M.I.MECH.E.

372 pp. Royal 8vo. 1927. 20s. net. (to members 12s. 6d. net).
Institution of R.E., Chatham.

The publication of this volume completes the Herculean task which

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was set Colonel Addison, who is to be congratulated on its successful accomplishment.

The eight volumes he compiled have been all published by the Institution of R.E., and deal with *Bridging*, *Geological Work on the Western Front*, *Military Mining*, *Supply of Engineer Stores and Equipment*, *Water Supply* (*France*), *Water Supply* (*Egypt and Palestine*), *and Work under the Director of Works* (*France*). There is also another volume on the *Signal Service* (*France*), written by Major R. E. Priestly.

The ground covered by this series of volumes furnishes an idea of the vast extent of engineering operations in the field. Truly an " engineers' war " when one thinks also of the work in factories at home on munitions and equipment. The work serves as a history of the war and to some extent as a manual of military engineering, illustrated by maps and photographs. In the volume on *Work under the Director of Works* (*France*), which covers such technical subjects as aerodromes, ammunition depots, bakeries, hospitals, hutting, incineration, and laundries, there are no less than 81 folded drawings. Readers who were on the Somme in 1916, or at Arras-Vimy Ridge, Messines, or Ypres in 1917, will find the historical part of *Military Mining* of interest.

Now to come to *Miscellaneous*, which we are more concerned to review. This is arranged in nine sections :—I, The Organization and Expansion of the Corps, 1914-18 ; II, Organization of Engineer Intelligence ; III, Camouflage Service ; IV, Concrete Defence Works and Factories ; V, Forward Communications ; VI, Machinery, Workshops and Electricity; VII, Anti-Aircraft Searchlights ; VIII, Inundations ; IX, Schools.

Those sections will now be considered in detail—but of necessity only briefly, as the *Miscellaneous* volume has appeared but a few days before the *R.E. Journal* goes to press.

I, Organization and Expansion, deals with the units and establishments of the R.E. prior to the outbreak of war in August, 1914, the expansion of the units on mobilization and after, and the subsequent increase of units—bridging, electrical and mechanical companies, tunnelling companies, searchlight company, labour battalions, and how they were transferred to the Labour Corps in 1917, field survey battalions and their formation, the sending to France of six works companies on aerodrome construction, the conversion of coast defence units into advanced park and base park companies, transportation units, army postal service, etc.

II, Organization of Engineer Intelligence, includes collection and circulation of information on field engineering in our own and allied armies, and with regard to the enemy's methods.

III, Camouflage Service, is arranged in three chapters—organization, production, and execution, providing most interesting reading, with illustrations and sections of various camouflage devices such as the construction of an observation tree, periscope tree, observation posts, covers for machine gun emplacements, etc.

IV, Concrete Defence Works and Factories, describes block shelters, pill-boxes, " Arques " pattern block, machine gun emplacements, layout of concrete factories, etc. Sectional drawings are given.

V, Forward Communications, treats of tracks and roads and the operation of tramways and their mechanical equipment, with plates illustrating

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ballast trucks, tramway trucks, trench boards and trench bridges, types of tracks, etc.

VI, Machinery, Workshops, and Electricity, considers aspects of warfare which were not adequately provided for in the original British Expeditionary Force, but which had to be quickly developed as the campaign proceeded, and led to the formation of Electrical and Mechanical Companies R.E. for the Armies, and, later, Army Workshop Companies, R.E. Particulars of the plant in various of the Army workshops are given.

VII, Anti-Aircraft Searchlights, is a summary of their development in France, which was necessitated by the new feature of night bombing by enemy aeroplanes, which began in the latter part of 1916.

VIII, Inundations, discusses the flooding of the Belgian coast by the Allies and the enemy and the use of inundations by the Germans as a defence against the tanks in other parts of the field. Their methods are described, and the advantages and disadvantages of flooding are considered.

IX, Schools, gives a short account of the work done and lessons learned at the Training School in connexion with the R.E. Base Depot and the School of Instruction for Officers Commanding and Second-in-Command of Field units. The Heavy Bridging School is described, not here, but in the volume on *Bridging*, and the Army Mines School is dealt with in that on *Military Mining*. Some of the rules for trench-work are the subject of divided opinion, but they were the views of men who came out of the trenches to be instructors and were, therefore, in touch with the real conditions at the front.

To conclude, all the volumes in the *Work of the R.E. in the European War* contain an immense amount of information, the study of which by members of the Corps is desirable in their own and the Corps' interests. Special prices to members of the Institution of R.E. are granted, and the Institution is to be congratulated on its courage in undertaking so monumental a publication when the War Office, on grounds of economy, could not do so. The work of Colonel Skey in producing the volumes after their compilation by Colonel Addison deserves the commendation and support of members.

MAGNUS MOWAT, Brig.-General, Reserve of Officers,
M.INST.C.E., M.I.MECH.E., M.I.E.S.,
Secretary, The Institution of Mechanical Engineers.

LES OPÉRATIONS EN MACÉDOINE L'EPOPÉE DE DOÏRAN, 1915-1918.

By Lt.-Colonel Nédeff, General Staff Bulgarian Army. Translated by Le Commandant Goetzmann, French Colonial Army. (Librairie Française et Etangére, Sofia). Price 8 fr. suisses.

Lt.-Col. Nédeff, who occupied a very responsible post on the Doïran front in Macedonia during the Great War, published some time ago the history of the struggles between the Allied troops and the Bulgarian

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forces. This account has been revised and edited by Major Goetzmann of the French Colonial Army.

The book covers the whole period of the campaign on the Doïran front in Macedonia, from 1915 to 1918. A short preface explains the reasons which forced Bulgaria to join the Central Powers. The book is divided into 6 Chapters. Chapter I gives the famous Ukaze of Tsar Ferdinand with which the operations began. It further indicates the organisation of the two Bulgarian Armies and their objectives. The operations of the second of these armies is given in detail, showing how it had to deal with both the Servian army on the west and the Allied, Franco-British force on the south (1915).

Chapter II deals with the operations in 1916. It refers to the stoppage of the Bulgarian troops on the Greek frontier as a great mistake, imposed upon the Bulgarians by German strategy and diplomacy.

This Chapter includes a description of the organisation of the Doïran-Vardar position and gives an account of the fighting there from the 9th to the 18th August, 1916.

Mention is made of the 25th English Division in the narrative, but this is a mistake, as the 25th Division was never in Macedonia.

It is interesting to note that only two Bulgarian Battalions and two Companies were engaged in these operations against one French and one British Division, a tribute to the extraordinary natural strength of the positions. The Bulgarian army seems also to have been very short of munitions and artillery.

Chapter III contains an account of the operations during the winter of 1916 and the spring and summer of 1917, including the British attacks on the " Pip " ridge and Doïran in April and May of the latter year. A high tribute is paid to the gallantry of the British troops in these actions, and it is stated that the Bulgarians buried no less than 40 British officers and 2,250 other ranks after the attacks. The present writer was a spectator of these operations, and can testify to the gallantry of the British and Bulgars alike, and to the heavy losses of the former.

The chapter also contains a critical review of the operations from the point of view of the lessons they teach.

Chapter IV describes the operations in the early part of 1918, and divulges the plan of the " Balkan Zug " to the south, which provided for a general offensive, but which was never carried out. To one who was much concerned with the preparations which we made to meet this long looked-for "Mackensen Push," this part of the book is very interesting.

Chapter V deals with the final battles 16th-20th September, 1918, and describes the break through of the Bulgarian lines by Allied troops at Dobro-polé. The author eulogises the successful efforts of the Bulgarian Army, in spite of very bad conditions, in withstanding the assaults of the British and Greek troops against the Doïran-Vardar line.

Chapter VI deals with the Bulgarian retreat, and suggests how the reverse at Dobro-polé might have been retrieved.

The book is illustrated by six good maps and contains also photographs of eminent commanders on either side although, curiously enough, there is no portrait of Sir George Milne, the British Commander-in-Chief in Macedonia.

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From a military point of view, perhaps the most important point brought out in the book is the constant struggle between artillery and the engineer and his fortifications. From the point of view of the Britisher, the salient feature is the high appreciation of the energy and gallantry of the British soldier, who is said to have displayed such valour and such astonishing energy. To one who had the honour to serve with the British soldier for some two years of this campaign, this is most gratifying reading. It is high praise, and high praise is always gratifying, but the praise of a gallant enemy is the most gratifying praise of all.

The book has been presented to the R.E. Library by Lt.-Colonel Nédeff, of the General Staff of the Bulgarian Army, and to him the best thanks of our Corps are due, not only for the gift but for the kindly thought which prompted it. It was accompanied by a critical review by Lt.-Col. K. D. Marinoff, also of the Bulgarian General Staff from which these short notes are principally taken.

G.W.

NATIONAL FRONTIERS IN RELATION TO INTERNATIONAL LAW.

By COLONNELLO VITTORIO ADAMI, Historical Section, General Staff, Rome, 1919. Translated by Lt.-Col. T. T. Behrens, R.E., late British Commissioner, Italo-Austrian Boundary Commission. With an appendix by the Translator. 8vo., pp.127. Price 10s. 6d.

Colonel Behrens has rendered a public service by translating Colonel Adami's book on *Frontiers in relation to International Law*. We are, as yet, very far from having emerged from the period of frontier delimitation, if we ever do emerge from it, and since Royal Engineer officers are very much concerned in the matter—for the duty of such delimitation very commonly falls on them—the book in question is one that should find many readers amongst the translator's brother officers.

Colonel Adami deals with the various kinds of boundary, natural or artificial; and, as regards the former class, with mountain boundaries, river boundaries, boundaries on lakes, and sea boundaries. As to artificial boundaries, he discusses those leading along roads, astronomical boundaries, and military boundaries. And then we have, as a sign of the times, aerial boundaries and the question of beaconing an air frontier.

Some more technical chapters are devoted to boundary marks, the delimitation documents, and boundary magistracies.

In the chapter on mountain boundaries, it is very properly pointed out that the crest line of a mountain range is, in general, distinct from the watershed. The author takes, as an exact instance, the case of the Chili-Argentine boundary, on which matter the King of England was asked to arbitrate in 1902. In the treaty between these two countries, which was signed in 1881, it was agreed that the boundary as far south as latitude 52° should be the Cordillera of the Andes. "La ligne frontière sera marquée dans cette étendue par les sommets les plus élevés des dits chaînes (Cordillères), qui partagent les eaux et passera entre versants qui s'inclinent de part et d'autre." Now, the summits are not, in general, on the watershed, and the terms of the treaty could not be carried out in

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their original form. It is well known how the King appointed a Commission, and how Sir Thomas Holdich took out an expedition and settled this difficult matter on the spot.

In the chapter on river boundaries we find some sound remarks on the undesirable character of such frontiers. Ahrens is quoted to the effect that rivers do not in reality form boundaries between peoples, " but rather serve as an artery,. . . . . a natural area. . . . .is so bound together by rivers and torrents that the two banks . . . should belong to one nation." Then there is a description of the distinction between the median line of a river, that is the line mid-way between the two banks, and the " thalweg " (blessed word), which is either the line of deepest soundings, or the stream line of fastest current. In the case of the boundary between Bulgaria and Turkey, after the war of 1878, the " thalweg " of the Danube had to be determined, and the President of the Commission proposed that this should be taken as the line most favourable to down stream navigation during the period when the river was at its lowest. Nice problems arise when a river changes its bed, or shifts its line of deepest soundings, or of swiftest current.

Lake frontiers are discussed, chiefly with reference to the Italian and North American Lakes. The latter are dealt with in the same manner as the high-seas. And, with regard to the high-seas, the question of the limits of territorial waters has to be decided. A recent decision of the Hague Court of Arbitration lays down that " concerning bays, the three sea-miles must be measured from a straight line, drawn across the body of water at the point where the body of water ceases to have the outline and characteristics of a bay."

There is, apparently, at present no common agreement amongst civilized nations as to the use of air frontiers, but it is undisputed that the sovereign rights of the State apply to the whole air space which overlies its territory. It is, of course, easy to imagine that it would be undesirable to allow free air traffic over certain areas, and it is not doubted that a country has the right to prohibit the passage of air-craft over, or in the neighbourhood of, its fortifications. But there is no international arrangement on the general question. No doubt this will come, and, when it does, international frontiers will have to be so marked as to be clearly visible from the air.

Generally speaking, the book deals with practice in Europe, and its point of view will be particularly interesting to those whose knowledge of such matters is chiefly derived from work in Asia or Africa. An African boundary, is, of course, a rough sort of thing, as compared with one in Europe. The reviewer, for instance, knows of an African boundary along which the boundary pillars are spaced at intervals of about 20 miles; one pillar, let us suppose, at Chatham, and the next at Woolwich ! But these African boundaries will require more exact demarcation in a not distant future, and it will be as well for those who may have to deal with such matters to read Colonel Adami's book, as translated and edited by Colonel Behrens. There is much in it that deserves study.

In conclusion, the reviewer would like to draw attention to the frontispiece which accompanies the first 110 numbered copies. It is an engraving of the Brenner Pass, showing also the two sides of the pillar erected

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on the Italo-Austrian boundary at this pass. The Italians have inscribed on their side of the pillar—HVCVSQVE AVDITA EST VOX TVA ROMA PARENS. The Austrians have countered this, on the other side of the pillar, with—FONTES SEIVNGO CONSOCIO POPVLOS. It should be added that it is understood that the inscription on the Italian side was the first to be proposed, and it was then up to the Austrians to find a suitable and friendly reply, as it were, for their side. These felicities give a pleasant idea of the relations which existed between the various nationalities on the Commission, on which Colonel Behrens was the British representative.

C. F. CLOSE.

THE MAGNETIC SURVEY OF INDIA, 1901-20.

Records of the Survey of India. Vol. XIX. Part I—History, Instruments, etc. Pp. 67. Part II—Tables of the Magnetic Elements, pp. 121. Part III—3 sets of diagrams and 9 maps.

Printed at the Geodetic Branch Office, Survey of India, Dehra Dun, 1923. Price 4 rupees, or 6 shillings and ninepence.

A magnetic survey differs from an ordinary survey much as pheasant shooting differs from firing at a fixed mark. A magnetic chart represents the values of the magnetic elements at a definite epoch, but it implies field observations extending over many years, during which the elements are continually altering. In addition to the secular change, which *may* be in one direction for a hundred years, but which is continually altering its rate, we have the diurnal variations, in consequence of which a field observation is unlikely to give the mean value for the day. Supposing, for simplicity, we had a magnetic observatory at the centre of an area, throughout which the secular and diurnal changes were each invariable. Then to deduce from a field observation the value of a magnetic element at a particular epoch, we should simply apply to the result of the field observation a correction, based on measurement of the observatory magnetograms, representing the difference between the values of the element at the observatory at the time of the field observation and at the fixed epoch. But in the case of a large area the secular and diurnal changes are different in different parts of the area, and a single magnetic observatory is quite inadequate. The survey started with five observatories, Dehra Dun, Barrackpore (near Calcutta), Toungoo (Burma), Kodaikanal in Southern India and Alibag (Bombay). Barrackpore was given up in 1915, leaving only four observatories, including Alibag, which is under the Meteorological Service. Even in a compact country shaped like a parallelogram, four observatories situated at the corners could not supply all the information desirable as to secular change, unless its law of variation throughout the area were very simple, and it was found necessary to supplement the observatories by 80 "repeat stations" scattered over the country. By repeating observations at these stations after 5-year intervals, a great mass of information was obtained as to the secular change. Including the repeat stations there were in all 1,481 field stations in India, Burma and Ceylon, including 4 in the Andaman Islands. The elements observed in the field were the declination (D),

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the horizontal intensity (H) and the dip or inclination (I). In a general way the regular daily range in D varies inversely as H. In India, H is very high, and the daily range of D correspondingly small. Again, near the equator magnetic storms chiefly affect H. Further, while secular change of D is much larger in the south than in the north-west of India—the mean annual change from 1909 to 1915 being about 6½′ to the west in Ceylon, whilst at Quetta it was practically nil—the change at all the observatories followed a very regular course, as is clear on inspection of the diagrams IA, IB, and IC. Thus D was a comparatively simple element to deal with. The results are embodied in maps 4 and 5. These show as black lines the isogonals (lines of equal D) for 1909.0 and 1920.0, and as coloured lines the lines of equal rate of secular change for the three periods 1902 to 1909, 1909 to 1915 and 1915 to 1920. In 1920 the line of zero declination ran across India in a generally E.N.E. direction, passing a little to the north both of Bombay and of Calcutta, and at no locally undisturbed place did the compass needle point as much as 4° out of the astronomical meridian. To the north of the agonic line declination is easterly. H was a more difficult element to deal with. As appears from the Kodaikanal figures in earlier volumes of the *Records*, the daily range of H is very large in the south. There is also a great difference as regards secular change between the south and the north. Between 1915 and 1920, H rose on the average about 40 γ (1γ=0.00001 C.G.S.) per annum in Ceylon, while near Quetta it was falling just as rapidly. Again, as is shown in the diagrams 2A, 2B and 2C, the secular change was by no means regular at any of the observatories. The absolute determination of H presents more difficulty than that of D, there being various instrumental sources of uncertainty, which are aggravated when H is as large as in India. In view of the rather numerous instrumental changes disclosed in Tables II to VI of Part I, it is by no means improbable that the apparent secular change irregularities are partly of instrumental origin, but some of the principal ones seem to represent the remarkable tendency in H to suffer a large depression after violent magnetic storms, which may take weeks or even months to disappear. Maps Nos. 6 and 7 deal with H for the same epochs as the D maps. Some 300 miles south of Rangoon, H reaches the value of 40,000γ, which is attained in only a very small area on the earth's surface.

Maps 8 and 9 give the isoclinals (lines of equal dip) for 1909.0 and 1920.0, and the corresponding lines of equal annual change. In 1920 the magnetic equator (i.e., the locus where the dip vanishes) crossed the northern part of Ceylon from east to west. In the south of Ceylon the south pole dipped 5°, while near Peshawar the north pole dipped 50°. Thus the range of dip in India is very large. The north pole is going down (or the south pole rising) rather rapidly all over India. In the neighbourhood of Quetta, the annual change between 1909 and 1915 reached 9′. Maps 10 and 11 relate to a derived element, the total force, for the two epochs 1909.0 and 1920.0.

Full particulars of the values of the elements at all the field stations appear in the tables on pp. 1 to 92 of Part II, and on pp. 103 to 116 the geographical surroundings of the 80 "repeat stations" are described.

The volume gives in a concise form the results of a very onerous piece

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of work on which the Survey Department deserves to be congratulated. The results, while specially useful for magnetic charts, are of general interest to magneticians. One doubt which presents itself is whether a larger number of observatories would not have been desirable. India is often compared as regards area with Europe, omitting Russia. But this European area has over 20 magnetic observatories. We learn from p. 2, Part I, that the original number 5 was decided upon by Sir A. Rücker and the Indian Committee of the Royal Society. But we know that Rücker thought that magnetic disturbance was practically uniform over an area as large as the British Isles, and that when allowance was made for differences of local time, the same was true of the regular diurnal changes. This is far from true, and with the knowledge now possessed Rücker would probably have desired a considerably larger number of observatories. The ultimate determining factor of course is the money available, but with a view to future possibilities it may not be amiss to point out the very big gap in the north-west. Observatories in Ceylon and in the north-east also suggest themselves, and if importance attaches to the east coast of the Bay of Bengal, an observatory there about 10°N. would probably be useful. At the present moment, owing presumably to financial stringency, only two magnetic observatories, Alibag and Dehra Dun, are in action in the whole of India. This seems very inadequate even for purely survey purposes, and from a wider scientific standpoint it is simply lamentable.

CHARLES CHREE.

EXCAVATIONS ON THE HILL OF OPHEL* AT JERUSALEM.

To the south of the Haram enclosure, in Jerusalem, there runs a desolate looking spur some six hundred yards long, a spur covered with cabbage gardens, with a few mean houses on it, and here and there some traces of excavation. This spur is, without doubt, the site of the original hill-top fortress which David captured from the Jebusites about the year 1000 B.C. It is the City of David. It is Mount Zion, the Joy of the whole Earth.

There is no site more rich in associations with the origins of our civilization than this miserable-looking hill; there is no site which more deserves to be excavated and explored; there is no site which brings us more definitely into touch with early written history. But it is only in comparatively recent years that it has been recognized for what it is.

In the year 1867, the Committee of the Palestine Exploration Fund obtained permission from the War Office to engage the services of Lieutenant C. Warren, R.E.,† to undertake exploration and excavation in Jerusalem, and in February of that year, Lieut. Warren and a party of Royal Engineers arrived in Palestine and commenced work, which was continued for more than three years.

* *Palestine Exploration Fund Annual*, 1923-1925. *Excavations on the Hill of Ophel, Jerusalem.* Published by order of the Committee, 2 Hinde Street, W.1. Quarto 216 pp. plus viii, with XXVI plates and 217 illustrations in the Text, 2 maps and an Air-Photograph. Price 40s.

† "Et ille quidem plenus annis obiit, plenus honoribus." (Ed., R.E.J.)

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The history of past excavations is briefly as follows: Lieut. Warren discovered, deep down in the rubbish of centuries, the remains of a great wall, on the eastern side of the Ophel Hill, towards the north, and he followed this wall for 700 feet. He named it justly, the Wall of Ophel. It has been shown in recent years by Father H. Vincent, to rest upon a Jebusite foundation; and there are analogies in its construction with the methods used in the construction of the walls of Troy, walls built sometime about 2000 B.C. But, from an historical point of view, Lieut. Warren's most interesting discovery was that of the great shaft and associated passages leading from the crest of Ophel to the Virgin's Spring in the Valley of the Kedron. Most scholars are of opinion that this is the veritable *Gutter* up which Joab climbed when David captured the city.

It is written that David said, "Whosoever smiteth the Jebusites first shall be chief and captain." And Joab the son of Zeruiah went up first and was made chief. And, in another account, we read that David took the stronghold of Zion, the same is the City of David. And David said on that day, "Whosoever smiteth the Jebusites let him get up the gutter (or watercourse)."

Of equal interest is the tunnel cut by King Hezekiah's orders through the rock, from the Virgin's Spring, which is Gihon, to the interior of the then existing bounds of the City at its Southern extremity, the Pool of Siloam. About the year 701 B.C., Jerusalem was threatened by Sennacherib; and Hezekiah took council with his princes and his mighty men to stop the waters of the fountains which were without the city, and they stopped all the fountains and the brook that flowed through the midst of the land, saying, "Why should the Kings of Assyria come and find much water." The tunnel then made by Hezekiah is some 600 yards long, cut through the limestone rock. Lieut. Warren and his party mapped the course of this tunnel in very difficult circumstances, the water being sometimes up to their necks. In 1873, Lieut. Conder again mapped the tunnel; and in 1909-11, the water in the tunnel having been diverted by the Parker Mission, Father H. Vincent made fresh surveys of the tunnel and of the other subterranean workings, some of these being pre-historic and, of course, long anterior to the time of Hezekiah. It was just inside the western end of this tunnel that there was found the celebrated Siloam inscription describing the meeting of the two parties of tunnellers who had worked towards each other from each end.

Then we have excavations in 1894-97 by Messrs. Bliss and Dickie, who discovered the remains of a Byzantine Church to the north of the Pool of Siloam, and also a paved street leading down the Tyropœon Valley to the West of Ophel. And the Parker Mission in 1909-11 enabled Father Vincent to find some prehistoric burial caves and a remarkable megalithic gateway near the crest of the Hill.

In 1913-14, and again in 1923-24, Mr. Raymond Weill, on behalf of Baron E. de Rothschild, carried out excavations at the southern end of the ancient city and discovered certain passage graves and a great isolated round tower, well outside the walls of the City to the east, and more interesting still, the remains of the Jebusite fortifications at the southern end of the Spur, so that we know the southern limit of the fortress.

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So, after this long introduction, we come at length to the subject of the book under review, namely, the excavations carried out in 1923-25, for the Palestine Exploration Fund, by Professor R. A. S. Macalister and the Rev. J. Garrow Duncan. An account of these excavations is given in an admirably produced quarto volume of over 200 pages, very fully illustrated and accompanied by two maps and an air-photograph. The work was undertaken at the suggestion of Professor Garstang, then Director of the Department of Antiquities under the Government of Palestine; the chief stipulation being that £5,000 should be spent on it. Of this sum, £2,000 was given by Sir Charles Marston; £1,000 by the *Daily Telegraph*; and £1,000 was voted by the British Academy, from the funds of the Schweich Bequest; the balance being paid by the Palestine Exploration Fund.

The work was confined to excavation in three fields, generally on the eastern side of the spur, and some 100 yards to 200 yards to the south of the present city wall of Jerusalem. A study of this book will show what a very skilled matter excavation is, or should be, nowadays. Professor Macalister clearly describes the various strata of excavation, beginning from the rock surface upwards. We find first of all, then, the rock surface with entrances to caves and an early trench, the depth of the rock surface varying from about 7 feet to 30 feet below the present surface. On the rock surface were found those mysterious, but not uncommon, evidences of primitive religion, cup-marks. Then, next above this, we find the Jebusite stratum; on the eastern edge there are some fine portions of Jebusite walls and inclined ramps, no doubt portions of the very fortifications from the top of which the Jebusites taunted David.

We then come to the Hebrew stratum, and above that to the Herodian, Roman and Arab strata. Perhaps the finest discovery of all was a stretch of the early Hebrew fortification which may be attributed to the time of David and Solomon. This fine piece of wall, called the Great Tower on the map, is a projecting flanking tower, 57 feet long and some 18 feet in the return. What its original height was, no one can tell; but about 25 feet is now visible, or was visible during the course of the excavations. "The masonry and dressing is similar to the masonry found at Megiddo and Gezer, which has been assigned to Solomon by Schumacher and Macalister respectively." They regarded the masonry of this class found on these sites as part of the repairs carried out by Solomon in accordance with the notice given in I Kings. . . . . "It is inferred that the upper part shews the repairs carried out by Solomon on the walls of the City of David." The masonry of the top eight courses differs from that below, in which the stones are not dressed and the face is plastered. The masonry of the lower portion is assigned to David, and the assigned date is confirmed by pottery found in the face of the wall.

As to the smaller finds, pottery of Neolithic, Early Bronze, Third Bronze age, Hebrew and Meccabæan dates are recorded; the trench in the northern field "was filled with earth containing countless sherds of the Middle Bronze Age (2,000-1,600 B.C.)." One ostrakon (inscribed sherd), was found, the writing on which is ascribed by experts to the seventh century B.C. "It merely tells us of the existence of three persons of whom we never heard before, of whom we even yet know nothing, and

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of whom we are not likely now to hear again. Thus does antiquity mock those who would pry too curiously into her secrets." There was also found a large number of the handles of Rhodian and other wine jars, inscribed in Greek.

But, in the main, these excavations, spread over more than half a century, have revealed to us the character of the Jebusite hill-top fortress; the outline of its walls on the east and south, the nature of its masonry and of that built in the reigns of David and Solomon. We have discovered primitive and complicated subterranean passages stretching back to a very distant past. We know that the Jebusites had a water-passage similar to that of Gezer. We know that the southern point of the fortress was, in Jebusite times, defended by a keep inside the wall of the fortress. We know all the details of Hezekiah's great engineering work, the tunnel, which was to prevent Sennacherib from finding and using the water of that ancient and sacred, serpent spring, Gihon—the spring which was, doubtless, the cause of the original settlement. And we know how the early Hebrew kings shut in the water of the Pool of Siloam, and how the later kings built a buttressed wall across that valley.

These and other things we know; but there is much, also, that we do not know. We do not know where David and his successors were buried, though it was probably somewhere on this small spur. We do not know the site of the Akra, and are doubtful about the mysterious "Millo." We have not yet traced the remains of the fortifications on the western side of the ancient city, though, as these were inside the walls of the later city, there may be but little left of them. We do not know the northern limit of the Jebusite fortress. There is, in fact, a great deal to be done before we can say that this wonderful site has yielded up all its secrets. Perhaps, one day, the Palestine Exploration Fund will again dig on Ophel. All who are interested in the present remarkable movement, for reconstructing and revivifying history by means of the discoveries of archæology, will hope so.

C. F. CLOSE.

SCOUTING ON TWO CONTINENTS.

By MAJOR F. R. BURNHAM, D.S.O., Chief of Scouts under Lord Roberts. Edited and arranged by Mary Nixon Everett. (William Heinemann Ltd., 1926). Price 15s.

This is a volume of reminiscences, to be followed, it is to be hoped, by others, of the famous American scout of whom Rider Haggard has said:—"Burnham in real life is more interesting than any of my heroes of romance."

Born and bred among the early pioneers of the Middle West and California, he grew up among the cow-punchers, gunmen and old time prospectors of Arizona. It was on the Mexican border fighting the Apache Indians that he learnt what scouting means.

Attracted to Africa, like many another American, by the reputation of Cecil Rhodes and the lure of the mineral resources of South Africa, he made his way with his wife and child to Durban. A long and dangerous trek with a donkey-wagon brought them to Victoria in Mashonaland.

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There meeting Dr. Jameson, he soon found himself enlisted in the Chartered Company's forces for service against the Matabeles. He served throughout the first Matabele War (1893), and his account of that expedition is a valuable addition to the little that there is in print on the subject. His description of the last stand and death of Major Wilson and his gallant patrol is more than thrilling. After the death of Lobengula in January, 1894, Burnham organised a prospecting expedition to the Zambesi, and then, in 1895, decided to pay a visit to his Californian home by way of Egypt and Europe. In Paris in January, 1896, he heard of the Jameson Raid and at once abandoned his visit and returned to South Africa in time to take part under General Baden Powell and Colonel Plumer in the Second Matabele War (1896)—an aftermath of the Raid. It was Burnham who, with Mr. Armstrong, located the notorious witch-doctor, the M'Limo, the instigator of the rebellion, shot him in his cave and so ended the war.

Burnham then returned to America and joined in the gold rush to Klondike. In Alaska he heard of the outbreak of the South African War, and in December, 1899, received a cable appointing him Chief of Scouts on the staff of Lord Roberts. He reached the Orange Free State in time for Paardeberg and the advance to Bloemfontein. In the disaster at Sanna's Post, he was taken prisoner by the Boers. The story of his escape from the prisoners of war convoy is as good as anything in " The Escaping Club." His next exploit was in company with an officer of Royal Engineers, Major A. G. Hunter-Weston, and a small party of Sappers who were sent to cut the railway line north of Kroonstadt behind the retreating Boers. It was during this raid that Sergeant Kirby, R.E., won the Victoria Cross. Later, Burnham carried out a similar raid between Johannesburg and Pretoria, but, in an unsuccessful attempt to blow up the line leading eastwards from Pretoria, he had his horse killed and was himself badly wounded near Irene. He returned to England, and was awarded the D.S.O., and given an honorary commission as Major in the British Army.

The book is a thrilling narrative of adventure, and is full of value to the young officer for what it has to say of scouting and scoutcraft in a series of " small wars." His criticisms on the conduct of operations are outspoken, but to the point. His appreciation of the characters of Cecil Rhodes, Paul Kruger, Jameson, Lord Roberts and many others whose names are linked with the development of South Africa are interesting, and his judgment on the aspirations and characteristics, good and bad, of the Boers is a kindly one.

He tells a good story against the British officer : " Some of the peculiar instructions occasionally given to junior officers by their superiors before sending them on patrol were brought sharply to my notice one night. When there was no longer even a dim glow from the sunset and the stars began to shine brightly, the C.O. of the cavalry patrol I was guiding asked me what I was bearing on to find the station at Irene. I pointed to a star not far from the western horizon. He said "Ah, yes ! That's right. Always use a star." We rode on, winding in and out and changing our course very often. After about two hours, the C.O. rode forward and said to me : " Burnham, I have been noticing for some time that you are

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not accurately bearing on the star you pointed out to me. Are you quite confident of your direction ?" It took a little time to convince him that his instructions to use a star as bearing, if followed out literally would soon reverse his direction. But however faulty his astronomy there was nothing lacking in his courage to attack the Boers, or to do his best to cover my movements when in contact with them."

Which reminds the reviewer of another star story in South Africa. A British Officer was taken prisoner by the Boers near the railway line running north and south, north of Kroonstadt, and was carried off by them in an easterly direction. At a point which he estimated was forty miles east of the line, he managed to escape, and after several days, moving by night and hiding by day, he stumbled up against the outposts of a British force occupying the town of Lindley. He had lived on mealies and Kaffir beer and was in an exhausted condition. When he had recovered sufficiently he was interrogated by the I.O. as to his movements since his capture. He explained that when he escaped from the convoy, he made up his mind to make his way back to the railway, which he estimated to be about 40 miles to the westward. Recognising the " Southern Cross," he therefore decided to march on the westernmost star of that constellation, and did so for about 30 miles when suddenly he was challenged by a British sentry. Discovering he was at Lindley, he asked if he was on the railway. He was told that Lindley was 50 miles east of the railway. He could not understand it. I doubt whether, if he is alive, he has yet realized why he was misled by the star. Lindley is about 30 miles due south of where he escaped.

In his account of the first Matabele War, Major Burnham several times mentions a native Fingoe scout, by name John Grootbaum—" the coolest and bravest black (he was black, not brown) of all my African experience." It may interest him to know, if he ever sees these lines, that John Grootbaum served as a scout with Plumer's Column from 1899 to 1902, and was killed by a Boer after the war for having helped the British. He was not only a brave and reliable scout, but invaluable in discovering and reporting at once if a strange native joined the column—no small matter when there were two or three hundred natives, drivers and others, with it. On one occasion he was following up the Boers in the Pietersburg (Transvaal) district when one of their wagons stuck in a drift. The Boers rounded up the natives in the kraal where J.G. was hiding and employed them to unload the wagon, which happened to be carrying the ammunition of the last " Long Tom " in the possession of the enemy. J.G. helped to unload and counted the number of rounds. Returning to his column he guided a patrol to the spot and followed up the spoor. Eventually the remains of the gun were found in a kloof, it having been blown up by the Boers in their retreat.

Soon after this he was sent from the Pietersburg line across country to the Middleburg line, a distance of over two hundred miles, to pick up any information he could of wandering Boer commandos and report it to the first British post he came to—and ask to be sent back to his column. He made his way on foot and unarmed, and duly reported, but the I.O. to whom he gave his information committed an unforgivable crime. Realising his value he used him scouting for his own purposes and refused to

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send him back by rail. Eventually J.G. returned on his own. He deserved a better end.

"Scouting on Two Continents" is better reading than a novel, and no officer can fail to benefit by Major Burnham's experiences in scouting, tracking, and horse-mastership, to say nothing of man-mastership and knowledge of the native mind.

The book lacks an index and a general map of the date at which the events that are recorded took place. It is to be hoped that in the promised second volume these deficiencies will be made good. There appears to be an error on page 331, where the Lieutenant Childs mentioned is stated to belong to the R.E.

H.B-W.

"THE DIVINING ROD."—AN EXPERIMENTAL AND PSYCHOLOGICAL INVESTIGATION.

By (the late) SIR WILLIAM BARRETT, F.R.S., and THEODORE BESTERMAN. (Methuen & Co., Ltd., 1926). Price 18s.

The book is written "with the object of investigating by means of historical researches, by the collection and collation of large numbers of contemporary cases, by the carrying out of experiments, and by a discussion of the results thus obtained, the claims made on behalf of "water-divining," or "dowsing." "

It contains a mass of indisputable evidence, proving that it is possible to find water, oil, metallic ores, coal and hidden objects by means of the divining-rod.

It is practically certain that the birthplace of the modern use of the divining rod is in the mining districts of the Harz Mountains in Germany. Dowsing was probably introduced into England in the latter half of the sixteenth century by German miners brought over to work in the Cornish mines. The origin of the words "dowsing" and "dowser" are unknown. The "rod" used by the dowser is generally of green wood, and generally, but not always, V-shaped, but may also be of metal or even galvanized wire. There have been dowsers who worked with their hands alone. The V-shaped twigs used by the celebrated John Mullins (1838-1894), were of pliable green wood about 15 inches in length, three-sixteenths of an inch in diameter at the points of the V, and about a quarter of an inch in diameter close to the junction. The wood generally employed is white-thorn, but the black-thorn, hazel, plum, apple, willow and bamboo are also used. The methods of holding the rod, and its action, are clearly illustrated by diagrams in the book.

Attention has recently been drawn to the subject by the appointment of an official dowser, an ex-officer, by the Municipality of Bombay, and it will be remembered that dowsing was successfully employed for finding water on the French Front during the Great War. Two authenticated instances in which a good supply of water was found by R.E. Water Supply units near Albert with the assistance of an amateur dowser, Colonel Hugh Rose, are described with full details on pp. 194-196, of the book; and amongst the numerous other examples mentioned there is a

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case in Derbyshire which is personally vouched for by the late Major-General R. H. Jelf, R.E. The authors have gone to great pains to obtain and record reliable evidence in each case investigated and in many of them plans of the locality are provided to illustrate the letterpress. The authors do not hesitate to give examples of cases in which the dowser has failed, or has not achieved complete success.

Dowsers are born, not made; and experienced dowsers are by no means numerous, partly because the gift is confined to a few, and partly because of lack of opportunity to test by digging the powers they may be known to possess with the divining-rod. An experienced dowser is able to estimate roughly the quantity of water available, as well as indicating the line and estimating its depth below the surface. Dowsers are not infallible, but the proportion of successes is far larger than is generally supposed. John Mullins is said to have been successful in nine cases out of ten. The record during twelve months in India of the official dowser recently appointed by Bombay is reported to be even better. It was by mere chance that John Mullins was discovered. In 1859, a water line had been indicated by the professional dowser Adams in a locality where Mullins worked as a stone-mason. The owner of the property having seen the professional at work thought he might discover a local man who possessed the gift; he got his employees to try what they could do with the divining rod. In Mullins' hands the twig reacted the moment he approached the line indicated by Adams, of the direction of which Mullins was unaware. A well was sunk and water found. Thereafter Mullins was frequently employed to find water, and eventually he set up as a professional dowser and well sinker. His two sons inherited the faculty, but were not so successful as the father. Accounts of the work of these men, and of about thirty other dowsers, professional and amateur, and of both sexes, are given and are supported by a mass of evidence.

John Mullins was a man of good reputation, and as a dowser was found to be thoroughly honest and trustworthy. Unfortunately, this has not always been the case with others of his profession, and consequently the dowser has come to be looked upon with suspicion by scientific men, and especially by geologists.

The authors, after reviewing the evidence which they have collected, come to the following conclusion :—" It is unnecessary to employ a dowser in districts the geological formation of which is known to fall under either of two heads. On the one hand, if the district is over porous or permeable rocks, water may readily be found almost anywhere. On the other hand, if the locality is over non-water-bearing rocks, water can, as a general rule, be found only where the impermeable or impervious rocks have been pierced. In the former case, the experienced well sinker can do the work; and in the latter, recourse must be had to a geologist, or, by preference, to an hydro-geologist. A large field is left to the dowser, in the numerous regions in which the non-water-bearing rocks have faults, fissures, joints, and the like, or are in a decomposed or shattered condition. We can, therefore, understand the reason why so many dowsers originate from Somerset; it is because this region is among the most typical examples of the condition just described. It is in such regions that the dowser should be employed, and it is under such conditions that he has scored some of his

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most striking successes.....Even where deep wells are necessary, experience has shown that it is sometimes advantageous to supplement geological advice by calling in a dowser, for though a definite water level may exist, the *quantity* found at a given spot is often a matter of chance."

The authors devote a chapter to the rationale of dowsing. The conclusion to which they believe an impartial student of the facts set out in their book must come, is as follows :—" The dowser, in our opinion, is a person endowed with a subconscious, supernormal cognitive faculty, which, its nature being unknown, we call, after Professor Richet, cryptesthesia. By means of this cryptesthesia, knowledge of whatever object is searched for enters the dowser's subconsciousness and is revealed by means of an unconscious muscular reaction, or, less often, by an obscure nervous sensation or emotion which produces physiological disturbances : or, very rarely, by means of direct supernormal cognition made conscious by a visualisation or hallucination. We do not believe that the accumulation of further masses of evidence, though of course this is not undesirable, will make the argument for these contentions any stronger. All that is required is the discovery of some fruitful generalisation which will permit the orthodox scientist to incorporate cryptesthesia in the canon of accepted and indisputable scientific knowledge."

The reviewer has recently had personal experience of a most successful example of the dowser's art. The dowser, a professional, located two underground water lines, one at about 22 feet and the other at about 100 ; the two lines crossed each other, and the dowser selected a spot in the deeper line, as there was reason to suspect the purity of the upper water layer. A boring was made near the point which was close to where the two lines crossed, and at a depth of 95 feet a supply of excellent water, giving 400 gallons per hour, was successfully tapped. The remarkable thing was that the dowser was in no way affected by the proximity of the two lines of water, and was able to peg out the direction of both lines of water accurately, and to estimate their strength. This was a case in which the geological conditions were complicated by the known existence of two deep parallel faults 300 yards apart, between which several deep borings, up to 200 feet, had been made in the vicinity some years ago without finding water. The new boring is through two feet of top soil, 87 feet of Sussex clay, and six feet of sandstone rock. The water flows on the top of another bed of clay below the sandstone. The upper stream of water located by the dowser at a depth of 22 feet has been traced to its outlet in a line of small springs on the hillside 150 yards from where it was located. Analysis proves it to be unfit for drinking.

It is worth while recording that modern water engineers decline to work on the " no water, no pay " terms of the old dowsers, such as John Mullins, who were prepared to dig the well themselves, if the dowser's fee was slightly increased, and be paid at a fixed rate per foot if a reasonable supply was obtained. The new boring referred to cost, as per estimate, £285, inclusive of the dowser's remuneration and expenses, and the installation of a wheel pump worked by hand and delivering into a tank 30 feet above the ground level.

The conclusion to which the military reader of this interesting but rather ' heavy ' work must come is, that an experienced dowser should

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be available at headquarters of any force in the field to assist the engineer officers responsible for water supply. The want of such an expert was severely felt in the South African war. Many lives would have been saved and much fruitless labour avoided if an experienced dowser had been available, for instance, during the long halt at Modder River. Amateur dowsers did their best, but the results were almost nil. Geological data can generally be obtained of a possible theatre of war, but a dowser with experience of local conditions is a *rara avis*.

The book is amply illustrated, and includes a very large bibliography and a complete index, and should find a place in every engineer library.

H.B-W.

K.A.R.

By MAJOR W. LLOYD-JONES, D.S.O. (Arrowsmith, 1926). Price 18s.

Major Lloyd-Jones has earned the gratitude of all who, at one time or another, have served either in, or with, the King's African Rifles, for his attractive unofficial account of the origin and activities of that, perhaps, too little-known Colonial force. This, young though it is in years, has already made history in British East African territories. But the book is of interest not only to its past and present officers, for it contains much sound advice to those who may desire to join that adventurous Corps in the future. It supplies, moreover, a fund of information to those who wish to learn something of the gradual development of our great East African possessions during the past forty years; since the activities of the K.A.R. cover a wide area, embracing Nyasaland, Tanganyika Territory (during and subsequent to the Great War), Kenya, Uganda, and British Somaliland; in all of which once remote regions, operations have been carried out, and those countries now protected, by units of the King's African Rifles.

It is, indeed, a fine record that the author marshals in orderly array before the reader. The ground he traverses is extensive, for he describes the diverse nature of the theatres in which the mobile K.A.R. have been called upon to operate, including the long drawn-out strain on native personnel while building up numerous fresh battalions for service in German East Africa (now Tanganyika Territory), to confront the elusive, but extremely able, Vorbeck von Lettow. He tells us much, too, concerning the strange medley of Africans that constitute the ingredients of this romantic force, which has won great distinction under the leadership of a mere handful of British officers of junior rank. Imbued with the spirit of adventure, while sympathetic towards those they are training, many of these young officers have quickly gained the complete confidence, and even affection, of natives who were but untamed savages a short while ago; and the dog-like devotion of these Africans, when properly treated, to their British officers, is strongly brought out by the author, who, one can judge, rigidly practised what he preaches concerning this important matter.

Within the limits assigned, it is only possible to refer but briefly to the contents of this interesting book. Nevertheless, the reviewer endorses

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fully all that his old friend of Uganda days, Major-General Sir Cecil Pereira, K.C.B., says in his Foreword, namely, that changes in East Africa have been so great and development so rapid that it is fortunate Major Lloyd-Jones formed the idea of writing the history of the K.A.R. now ; for the longer such a work awaited an author the more meagre would be the results, since records of expeditions were necessarily scanty where pens, ink and paper were scarce, while many called upon to make reports were not much given to their use.

Major Lloyd-Jones has proved himself an ideal author for the task, obviously a labour of love on his part ; for, like many who have drunk deep of the waters of East African life and travel, it is clear that his heart is still in the country where he so much distinguished himself. The book is admirably illustrated with 43 photographs and a map, which increase the interest of the letterpress ; while a carefully compiled index at the end adds to the value of this attractively got-up and well-written record of stirring events.

H.H.A.

THE DAYS OF MY LIFE.

An autobiography, by SIR H. RIDER HAGGARD. Edited by C. J. Longman. 2 vols. (Longmans, Green and Co., Ltd., 1926). Price 28s.

A book to be read by all who are interested in the history of South Africa. Sir H. Rider Haggard was private secretary to Sir Theophilus Shepstone, when the Transvaal was annexed in 1877, and he throws a good deal of new light on the reasons which influenced Shepstone in deciding on the annexation, and carrying it out on his own responsibility. He was convinced that if he did not intervene and plant the British Flag at Pretoria, the Zulus, whose impis were all ready on the border, would sweep the Boers out of the Transvaal. By bringing the republic under the aegis of Great Britain, Shepstone was able, thanks to his personal influence with Cetewayo, to induce the Zulus to withdraw. It was a marvellous piece of bluff on the part of Shepstone and the handful of Englishmen with him. The Home Government approved his action when the annexation was a *fait accompli!*

H.B-W.

"OLD STICK-LEG."

Extracts from the Diaries of Major Thomas Austin, arranged by BRIGADIER GENERAL H. H. AUSTIN, C.B., C.M.G., D.S.O. (Geoffrey Bles). Price 10s. 6d.

Such was the name by which the veteran officer with the wooden leg was called by his great-nephews, who used to meet him tramping along the Whiteladies' Road at Clifton.

Thomas Austin was born on December 18th, 1794, and received his commission in the "35th" or The Sussex Regiment of Foot on May 17th, 1810. From the beginning of his service he appears to have kept a diary which is indeed remarkable for its power of vivid description. He joined

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his regiment at Shorncliffe and accompanied it to Guernsey a year later. At that time Napoleon was expected to have designs on the Channel Islands as a suitable point from which to assail England, and the whole coast line was vigilantly guarded by pickets. (On one occasion 'Little Tommy,' as he was affectionately called by his brother officers, captured a boat containing ten French Officers who had escaped from England and had put in to Doyle to get water).

In October, 1813, he went home on leave in the sloop *Chesterfield*, which after a brush with a privateer arrived in safety at Weymouth.

He had only been at home a few days when he heard his regiment had been ordered to Holland as part of the force under Sir Thomas Graham. This British expedition was intended to combine with a Prussian army under Bulow in an attack on Antwerp.

Austin immediately proceeded to join his regiment at Ramsgate, and after some confusion, caused by bad staff work, it eventually embarked at Deal.

The diarist tells us that there was a certain apprehension lest the disastrous mistakes of the Earl of Chatham's expedition of 1809 should be repeated. But he himself was full of keenness, and as an officer of the Light Company was one of the first to land on the Island of Tholen on December 17th, 1813.

He describes in intimate and picturesque detail the conditions which officers and men had to endure throughout the winter campaign, the frightful weather, the poor rations, the lack of fuel and the bad staff work. The bread served out to the troops was made of rye of inferior quality, so coarsely ground that it resembled a conglomeration of sawdust and soot; Schnapps was served out somewhat too liberally; at one time meat was issued in the hoof in the shape of lean cows, and the space of one hour was allowed on the march for killing, cooking and eating this ration.

An advance was made by Sir Thomas Graham towards Antwerp, and after several skirmishes an attack was made on the French at Merxem, a village three-quarters of a mile from Antwerp. During the skirmishing young Austin had the good fortune to save the Duke of Clarence (afterwards King William IV), from capture by the French.

Owing to the failure of the Prussians to co-operate in the attack on Antwerp, Sir Thomas Graham ordered a retreat, much to the surprise and disgust of the troops who had turned the French out of Merxem. Rozendaal was reached on January 16th in a blinding snowstorm.

The advance against Antwerp was renewed early on January 30th in a fearful storm of rain, snow and hail, which turned the ground into slippery sheets of ice. During the advance the Light Company was nearly cut off in a skirmish on Braeschaet Heath, but owing to the resource and courage of the Captain, Alexander Shaw, whom young Austin justly admired, the company was able to hold out until reinforcements arrived.

It was on February 2nd, during an attack on a dyke on the right of the line, after Merxem had been re-captured, that Austin's left leg was shattered below the knee by a cannon ball. He never lost consciousness but encouraged his men to further efforts. After some delay he was carried to the rear attended by his faithful servant, John Hope. Preparations were

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made for amputating the limb at Merxem, but that place being found too near the front, he was taken in a wagon to a Chateau at Braeschaet. An operating table was extemporised with bricks in the kitchen, whilst the instruments were laid out ready on the dresser. In these days of anaesthetics, one cannot help taking a morbid interest in the sensations of one who had to undergo an amputation without aid. Austin even refused the profered alchohol, feeling confident that he would not sink. It is consoling to know that he did not find the pain caused by the sawing of the bone and marrow worse than that occasioned by the rest of the operation.

Many gruesome stories are told of the medical arrangements in the army of these days; Austin seems to have been rather fortunate in falling into the hands of two good surgeons so soon after he was wounded.

From the accounts of participants the diarist tells of the siege of Antwerp, and of the disgraceful episode of the assault on Bergen op Zoom. This place, the strongest fortress in Dutch Brabant, was occupied by us after an assault, the success of which seems to have stultified the wits of the officer in command, General Cooke, for after remaining inactive in the place for some hours he allowed his troops to be turned out or captured by a smaller force of French. Sergeant Townsend of the Guards, however, refused to surrender, but with thirteen others cut his way out to freedom. He was many years later made Steward and Porter of Walmer Castle by the Duke of Wellington.

On April 1st, 1814, Austin sailed for home in the *Urania*, which owing to the supineness of the Dutch pilot, was nearly shipwrecked on a sandbank.

In July, he joined the Depot at Chichester, but retired after the battle of Waterloo, realising that his active military career was over.

In a commission dated July 27th, 1820, he was made Fort Major of the Fort of Duncannon in the County of Wexford, apparently as a reward for his war services and for saving the Duke of Clarence.

He spent 50 years at Duncannon, engaged mostly in literature, sport and geological excursions, and then settled at Bristol, where he died on March 25th, 1881.

This is a most entertaining book, presenting a vivid picture of life on active service in Napoleonic times, and unconsciously revealing the character of one who was a brave soldier and a humane and cultured gentleman.

A.H.B.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

(*July*, 1926.)—Commandant Desmazes concludes his excellent series of articles entitled *Les débarquements Alliés aux Dardanelles* in this number. The evacuation is passed over rather too rapidly ; one would expect some indication of the elaborate preparations required, but the writer's conclu-

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sions on the whole series of operations are of considerable interest. While realising the magnitude of the failure and setting forth clearly most of the contributory causes, he considers that the Turkish Army was so shattered by the severity of the fighting that the foundation of our eventual successes in the Near East is to be found in the Dardanelles operations.

In concluding *La Guerre Chimique*, Chef d'escadron Paul Bloch describes all the chemical materials which go to make munitions of war, and points out the great superiority of the German chemical industry at the outset of the Great War. If it had not been for the German chemists and this industry, Germany could never have held out so long, quite apart from the invention of gas as a weapon. The writer points out the efforts made by the French to set their chemical industry on a more secure footing, but is of the opinion that a great deal more work requires to be done in the interests of security.

Commandant " T " concludes his article *L'armée Anglaise et ses grandes manœuvres de* 1925 with a brief but clear description of the actual operations, and a reasoned criticism of the results obtained. The outstanding feature appears to the writer to be the immutability of the principles of war, whatever the changes in armament. The chief lessons drawn are the continual need for reconnaissance, the difficulties of co-operation between arms moving at different speeds, and the necessity for definite regulations on the use of mechanical forces. The air operations are well commented on. It is comforting to find that the writer considers that, in spite of the mistakes made, our army " is more than ever capable of intervening, with decisive results, in a war of some duration on the continent."

The operations are well illustrated by sketch maps.

Le Cinéma dans L'armée, by " X," emphasizes the value of training by eye rather than by ear, especially for a short service army. The procedure of preparation and instruction is well outlined, and a list of military films appended.

In *Notes sur la Conduite d'une Brigade mixte au Maroc septentrional*, Colonel Duffour, who has been for some time a brigade commander in Northern Morocco, discusses the composition of mixed brigades and the methods to be employed in operations in this part of Africa. The special application of the principles, laid down in the regulations, to mountain warfare is clearly brought out in these notes. As usual, co-operation between the various arms offers great difficulties, and it is interesting to note that the infantry of Colonel Duffour's Brigade were trained to attack any area which received an artillery bombardment, the duration of such bombardments and the subsequent lengthening of range being agreed upon beforehand when circumstances prevented close liaison between the two arms.

Une Opération au Levant ; l'affaire de Medjel-el-Chems, by " X," is a short description of an action against the Druses near Mount Hermon. The capture of the village of Medjel-el-Chems produced important political results ; but with the somewhat meagre sketch map supplied it is difficult for anyone unacquainted with the country to visualise the operations clearly.

(*August*, 1926.)—Commandant Janet's *Action d' une Division encadrée dans une offensive d'ensemble* describes the advance of the 48th

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Division of General Mangin's Tenth Army at the end of August, 1918. The general procedure of the operations of a centre division taking part in a big offensive is familiar to most officers who served in France towards the end of the Great War. The chief interest in this instalment is the method by which the enemy's forward zone was driven in by the French covering troops on the days preceding the main attack on August 20th, which was delivered by fresh formations which came into line during these preliminary operations. The article is illustrated by a somewhat inadequate sketch map, and ends with the close of the first day of the main attack.

The first instalment of Lieutenant-Colonel Paquet's *Formations des Officiers de renseignement. Organisation d'un stage au corps d'armée*, appears in this number. The writer gives a detailed and valuable description of the practical side of a course for Intelligence Officers organized by the Fourteenth Army Corps, and begins a detailed account of an actual paper scheme carried out during the course. Staff and regimental (including Air Force) officers take part in the course, the greater part of which consists of exercises without troops and controlled with great care by the officers of the Directing Staff, who criticise the exercises by stages as they develop.

General Rouquerol, in *La prise du fort de Douaumont*, begins a description of the operations of the 7th and 8th companies of the 24th Brandenberg Regiment, from the narrative of Lieutenant von Brandis, who commanded the latter company. The article combines a severe criticism of the Prussian officer's boastfulness and bias, with an outline of the contents of his narrative; as a result, the actual operations are difficult to follow clearly. What does stand out, however, is the overpowering effect of the German bombardment compared with the inefficacy of the French artillery; apparently the heroes of Douaumont (as the two company commanders have been acclaimed) remained in almost continuous touch by telephone with battalion headquarters, while the French communications were almost entirely destroyed.

In *Le problème du char de combat en* 1926, Lieutenant Colonel Pigeaud deals mainly with the capabilities of the existing "Renault" tank. Referring first to a previous series of articles in the *Revue*, the writer expresses the opinion that light, battle and super-heavy tanks will be required in future, with armaments ranging from the machine gun to the 6-inch gun. Turning to the "Renault," he discusses in considerable detail its employment in the various operations of war. The weak point of the contention that this type of machine is still generally satisfactory appears to lie in the necessity for lorry transport for a proportion of the tanks of each regiment. One can only wonder what would be the result of putting "Renault" tanks on 7-ton lorries in time of war.

Lieutenant-Colonel de Nerciat's article, entitled *A propos du cinquantenaire de L'Ecole supérieure de guerre*, reviews briefly the ceremony of the 50th anniversary of that famous institution, and draws attention to the success attained by some of its greatest professors and pupils.

(*September*, 1926.)—The second instalment of Commandant Janet's *Action d'une division encadrée dans une offensive d'ensemble* describes the exploitation by the 48th Division of its success on August 20th. By the

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evening of August 22nd, thanks largely to a brilliant operation carried out by a battalion of the 13th Tirailleurs, the division had advanced several miles up to the Oise-Aisne Canal. It is difficult to study the operations closely, although they are clearly described in considerable detail, owing to the inadequacy of the two sketch maps provided.

Lieutent-Colonel Paquet completes his article *Formation des Officiers de Renseignements. Organisation d'un stage au corps d'armée* in this number. The instalment requires to be read in conjunction with the previous one, as it deals with the development of the intelligence scheme, the earlier stages of which have been previously described. The indications issued by the directing staff to members of syndicates representing regimental intelligence officers, are of particular interest, ranging from captured documents to fragmentary reports of French " listening sets." The article concludes with an excellent guide for the intelligence staffs of the various formations with regard to the preparation of a plan of action, by which the maximum information can be obtained about the enemy's dispositions, both from a general point of view, and as affecting specially the plans of the higher command.

General Rouquerol completes his article *La prise du Fort de Douaumont* with a description of the actual capture and occupation of the fort, still drawn from the writings of Lieutenant von Brandis, commanding the 8th company of the 24th Brandenburg Regiment. According to the German description the operation was a brilliant feat of arms, whereas, in fact, the fort was practically unoccupied by the French ; but this does not affect the rapidity with which the German regimental officers seized a heaven-sent opportunity to capture an important tactical locality, while there was little excuse for the French failure to defend it.

L'aviation de bataille chez les Allemands, by Commandant " T," is an outline of the development of aircraft designed to attack the enemy's troops so as to produce decisive results in battle. The German policy is to form a special branch of the air service for these low-flying attacks, but the author has doubts, which will be shared by a good many British officers, as to the value of low-flying attacks as compared with other forms of air action. The article is interesting in showing clearly the trend of German official doctrine on this subject.

Lieutenant Navereau, in *L'ustensile en Argent*, describes an old war-time method of taxation instituted in 1650, by Louis XIV., and discontinued after the Seven Years' War. This tax was levied during the winter on districts which did not have to support troops in winter quarters, and the proceeds were set aside for the payment of the troops, and provision of their equipment for the coming summer's campaign. The tax was very profitable and, on the whole, equitable, in that the burden of the war was spread over as large a population as possible.

REVUE DU GENIE.

(*September*, 1926.)—*Electrification in Stationary Warfare.* A summary of the electrical installation in the 3rd Army Area of the German Army up to 1918. High tension distribution was carried up to within 7 to 10

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kilometres of the front on some 400 k.m. of lines, and over 1,000 k.m. at 380-115 volts, with a total installed supply of 8,300 K.V.A. This included a large number of small installations over 200 in number, output some 4,000 K.V.A. These installations provided power for some 700 motors and 80,000 lamps, serving workshops of all sorts and even ice factories and cinemas—not to mention an extensive system of electrified wire entanglements.

Destruction of communications and demolitions (continued). Experience of insufficient damage done on the Russian front taught a lesson that was made good use of in the withdrawal to the Hindenburg line—preparations for which extended over five weeks, and which was described by Ludendorff as a "brilliant exploit." The article describes shortly the general nature of the damage done and the methods used in the French Army for facilitating the advance. A list of bridges built by the French 3rd Army is given. Sketches of various booby traps are included.

The duty of Engineers in the Organization of Positions. Post-war regulations lay down very clearly that the infantry must prepare their own defence works. The duty of the engineers is described as :—

"In the defensive to prepare or improve communications, prepare demolitions—and may share in organization of ground so far as concerns certain special works," and further to carry out "exceptionally and in case of urgency, works that have to be completed in a very short time."

These regulations are the logical outcome of the great changes that have taken place in infantry organization and weapons, and may be justified in theory. But in practice they are untenable. In peace the infantry have no facilities whatever for training in construction of field works, whilst in war they are usually too exhausted by marching and fighting. Moreover, in war every work becomes a special and urgent one.

The prime business of the engineers is to help the infantry to perform their heavy tasks, and the engineers must be trained in peace so as to be be able to do this.

A dangerous post-war tendency has been to label the task of the Sappers as simply "communications." The writer asserts that there are two great tasks, "Communications" and "Fortifications," and that sometimes one and sometimes the other will be preponderant. The writer apparently abandons any idea of revising the peace training of the infantry.

He goes on to discuss the duties of the Engineer Command in relation to organization of ground, pointing out that regulations direct that the Engineer Commander shall take part in the reconnaissance and preparation of plans and orders, and is the immediate assistant to the Force Commander for all technical matters in the orders to be issued. The writer would rather define the duty as "the immediate assistant for everything concerning the organization of positions," on the grounds that tactics and technicalities are inseparable in such matters.

The 5th Public Works Congress. Summary of papers read upon the progress of development of work in harbours, and inland waterways, railways and roads.

(October, 1926)—Demolitions and Repairs of Communications—(continued). In February, 1918, G.Q.G. directed the preparation of a pro-

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gramme of inundations and demolitions between Arras and Coucy le Château, and approved instructions for wrecking four railway bridges in the British area on March 7th. But the enemy's attack on the 21st March, and their rapid advance, showed that on both the French and British fronts the demolitions effected had been inadequate. On appointment as Commander-in Chief of the Allied forces in France, General Foch issued orders on March 26-27 to the several commanders of groups of Armies directing them to hold their positions, and containing no mention of demolitions. But early in April, arrangements were made for such, and for inundations in the north, and evacuation and wrecking of Dunkirk. When the Germans attacked on the Chemin des Dames, May 27th, no higher command had dreamt of such success, and insufficient detailed programmes had been prepared. In fact, at 4.15 p.m., on 27th, G.Q.G. directed that the bridges must be preserved.

The writer quotes from a report of General Duchêne (commanding VI Army) stating that all preparations for demolition of bridges were ready and checked onMay 26th. The charges for bridges in the British XVII Corps were loaded by 6 a.m., 27th, but the general order to load the charges for bridges was given at about 8.30, which was in many cases too late, and discretion to Corps Commanders to destroy the bridges was given at 10.10 a.m., but the message to the British IX Corps was not sent, communications being interrupted. Some other orders did not reach their destinations.

The failure to destroy so many bridges led G.Q.G. to delegate authority to Armies to carry out demolitions, and on the Marne the XXI Corps Commander delegated the duties to divisions—with successful results—where all bridges were destroyed, and none prematurely. The writer gives in detail two examples indicating, even when every precaution had been taken, the difficulties of deciding on the spot the moment to fire the charge.

Elaborate new orders were issued on July 6th, allotting responsibility to higher or lower commands according to the relative importance of certain categories of works, while in every case the engineers responsible were to receive executive orders from a staff officer.

The writer goes on to quote orders given by Army Groups for the repair of roads during the final advance, and describes in some detail the methods in force in the 31st Division N.E. of Coucy le Chateau, through the St. Gobain Forest, and enumerates the dates at which many bridges were restored.

The writer concludes with an enumeration of the railway demolitions in Belgium and France in 1914.

The 5th National Public Works Congress (*continued.*)—Summary of papers on waterworks, water supply, drainage, legal matters and mines.

A Protractor for Trisecting Angles. A description.

(*November*, 1926).—*Destruction and Repairs of Communications* (*continued.*)—Summarises the damages to railway bridges, tunnels and tracks in France, and the dates of repairs by both forces in the first year of the war. Also the repairs to railways in 1917 after the complete destruction in the German retirement. The damages far exceeded expectations—so much so that 10% only of recovered material was usable, even after repair (*to be continued*).

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The Adventures of a Pontoon Train in Syria. Describes the painful journey of a train of pontoons by rough roads and inundated country round the Gulf of Alexandretta in 1920.

The Destruction of Structures employing Wire Cables. Describes an ineffective attempt to destroy a suspension bridge by firing gunpowder charges in the centre of the span. The bridge was subsequently quickly and simply broken by lighting fires under the cables.

(*December*, 1926).—*The Supply of Railway Sleepers during the War.* A summary of the organisation for provision, distribution, and cost and qualities provided, together with a description of the system in force before the war.

The Instruction of Engineer Units in the Organisation of Positions. The author finds that the combination of technical instruction with tactical situation presents difficulties; that the supposed presence of an enemy is apt to be ignored, and the necessary working discipline neglected.

He suggests that all detail work by N.C.O.'s should be based upon schemes previously worked out on the ground by the senior ranks under the supervision of Divisional Engineers Staff and accompanied whenever possible by Infantry Officers.

As regards rank and file he suggests that detailed instructions in actual execution of work should be followed by the construction of work under technical conditions and strict service conditions, including night work.

On manœuvres, when ground cannot be broken, useful instruction can be given in organising working parties and issuing tools and intelligent selection of practicable sites for work.

The Siege of Montauban. Extracts from the diary of M. de Pontis, published in 1678, describing various acts of heroism performed by the author.

Destruction and Repair of Communications in the Great War (continued). Sums up the reconstruction of main lines in the areas of the French Armies from July, 1918, till the Armistice.

Points out that on that date rail-head was some 100 k.m. in rear of the troops.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1926. TOME II. NOS. 1—3 INCLUSIVE.)

Les Opérations de l'Armée Belge (1914—1918.) The final phase of the defence of Antwerp is dealt with in Nos. 1 & 2 of the *Bulletin*. Early on the morning of October 9, 1914, the Belgians were still holding Sectors 5 and 6 and the forts in Sectors 1 and 2; directions for the active defence of those parts of the Citadel still held by the Belgian fortress troops were still being issued by Gen. Déguise. But the *morale* of the defenders, it is evident from the narrative, had by this time been reduced to an exceedingly low level. An attempt was made, for instance, to provide against the passage of the Scheldt by the enemy at the "Tête de Flandre," a Belgian fortress battalion being directed to take up a position there. However, the troops were completely out of hand, and could not be induced to put up a fight. Reports reaching Gen. Déguise at Calloo

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indicated that the Germans were on the point of crossing the Scheldt; later, it transpired that these reports were entirely false. At a conference held by Gen. Déguise at his H.Q., at 8 a.m. on the 9th, at which the Commandants of Sectors 5 and 6 were present, a very gloomy view of the situation was taken by the subordinate commanders. Nevertheless, Gen. Déguise was reluctant to hand over the Citadel to the Germans until, at least, they had delivered an assault against the defences. But the fact is that the control of the situation had already passed out of his hands, and, in certain cases, subordinate commanders were issuing orders on their own initiative. Later in the day he appears to have realised that the defence had collapsed, and at 18.30 o'c. he directed his Chief of Staff, General Werbrouck, to get into touch with the German H.Q., with a view to opening up negotiations for the surrender of the Belgian Citadel. In consequence, Gen. Werbrouck proceeded to the " Tête de Flandre "—the enemy had been reported to be there—but finding the locality still free from the invaders, he returned to the Belgian H.Q. at 22.30, and reported accordingly. By this time Gen. Déguise was fully convinced of the uselessness of any attempt to prolong the defence of Antwerp, and at 3 o'c. on the morning of the 10th directed Gen. Werbrouck to make another attempt to get into touch with the enemy for the purpose of arranging the terms of surrender. At this time the troops under his command were in full retreat.

At dawn on the 9th, the Germans found that Forts Nos. 4 and 5 had been evacuated by the Belgians, but apparently were still without knowledge of the complete collapse of the defence; however, von Beseler ordered a cessation of the bombardment, and sent a staff officer, Captain von Herringen, with a letter addressed to the " Commander of the Allied Troops " inviting him to surrender the Citadel. About the same time, rumours of the evacuation of Antwerp reached the Civil Authorities in the City; this fact seemed to be confirmed by a report from the police stating that the Fortress H.Q. were unoccupied. Instructions had been given to Gen. Maes to keep in touch with the Civil Authorities in the City, but he does not appear to have done so, and his whereabouts were unknown. The Civil Authorities were now placed in a most difficult position; left to their own resources they held a meeting at the Hotel de Ville and fully discussed the situation. They came to the conclusion that, in the interests of the civil population, their best course would be to get immediately in touch with the H.Q. of the besieging force. A deputation consisting of prominent civil officials accordingly set out between 7 and 8 o'c. on the morning of the 9th, for the German H.Q., then at Thildonck. The deputation being unaccompanied by a military officer, von Beseler was at first unwilling to enter into any negotiations with the members composing it; however, in order to save time, he proceeded at once to Contich and directed the Belgian deputation to wait upon him there at 15 o'c.

On arrival in the City, Captain von Herringen could find no military officer to whom the communication entrusted to him could be delivered, and was therefore unable to fulfil his mission. He proceeded, in consequence, to Contich, where he arrived shortly after his Chief; he confirmed the accuracy of the information as to the evacuation of Antwerp by the Belgian troops, conveyed to the German commander earlier in the day by the Belgian deputation. In these circumstances, von Beseler presented

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his terms of surrender to the Belgian deputation when it waited upon him for the second time as arranged ; he cut short an attempt which was made by the latter at this second interview to open a discussion on the conditions contained in the document laid before its members for signature. The Belgians, therefore, appended their signatures to the document—containing the German conditions—the text of which is set out in the original article—at 5.40 p.m. (Oct. 9).

Rumours concerning the events mentioned above soon reached the commanders of the forts in Sectors 1 and 2 ; with a view to preventing these works falling into German hands, they proceeded at once to destroy them as far as possible.

Gen. Werbrouck, on his second attempt to do so, succeeded in getting into touch with the Germans ; this occurred at 5.45 on the morning of the 10th. He crossed the Scheldt at about 6.30 a.m. and was taken to the Hotel de Ville, in Antwerp ; there he met the Belgian Civil Authorities, and also the Staff Officers representing von Beseler. It came as surprise to him to learn that the German authorities had arranged for the surrender of the Citadel alone with the Civil Authorities ; he informed himself of the contents of the document—known as the " Convention de Contich "—executed by the Belgians and the Germans, and, finding nothing in its terms in conflict with the instructions given him by Gen. Déguise, he ratified the terms of surrender on the latter's behalf, and duly reported the fact to his Chief.

It would appear that a misleading impression has been created in Belgium by accounts published concerning the first of the Belgian sorties—Combat d' Impde (Aug. 24)—delivered from Antwerp. Since the date on which the number of the *Bulletin*—i.e., No. 10 (Feb., 1921)—dealing with these operations was published, much additional information on the subject has come to hand ; in consequence, a revised account of the operations in question has been prepared and is published in No. 3 of the *Bulletin* under notice.

Le Bataille de Mons. An account of the first collision between the B.E.F. and the German Army in 1914 has been prepared by Major von Egro ; it is based largely on the History of the Great War compiled by the Historical Section of the Committee of Imperial Defence. The first two parts of this story are published in Nos. 1 and 3 of the *Bulletin.*

La verité sur la défense de Namur en 1914. During the period Oct. 1923-July, 1925, the *Revue Militaire Suisse* published a series of articles by M. Jean Fleurier entitled " Une légende. La faillite de la fortification permanente pendant la grande guerre." Col. Merzbach and Capt. Comdt. Herbiet, of the Belgian Army, contend that M. Fleurier had not sufficiently complete information at his disposal to enable him to deal satisfactorily with the subject discussed in the articles above mentioned, and they assert that, in consequence, some of the deductions drawn by M. Fleurier in relation to the defence of Liège, Namur and Antwerp are erroneous. The two Belgian officers named have written an account—which they claim is more accurate than earlier accounts—of the frontier battles fought in Belgium in 1914 ; their account is based on the more complete information which is now available ; the first part thereof appears in No. 2 of the *Bulletin.*

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Emploi de l' aéronautique de corps d' armée. The original article, which is an important and interesting contribution relating to functions of the "Fourth Arm," is published in No. 2 of the *Bulletin*; its author deals in considerable detail with the several problems connected with the employment, in military operations of some magnitude, of the aerial arm in combination with land forces.

Le vide du champ de bataille. The expression "le vide du champ de bataille" was coined to be descriptive of the seeming "emptiness" of the territory occupied by the combatants of the Great War. The early experiences of the Great War showed that former methods of obtaining "intelligence" were by themselves inadequate; in consequence, aerial photography was called in aid to supplement them. The very remarkable results obtained by this means are described in an article by Capt. Comdt. Menzel, the first part of which is published in No. 2 of the *Bulletin*.

W.A.J. O'M.

HEERESTECHNIK.

(*July*, 1926). *The Chemistry of Smoke-production*, by Dr. Stampe.

How are we to produce the particles of the size pointed out in the May No. of *Heerestechnik*, as necessary for smoke or mist for screening purposes? From the nature of things it can happen in two ways, either through breaking up larger particles of matter or through condensation of smaller particles, *i.e.*, one proceeds to what is required either from solids and fluids, or from vapours and gases. Many solids can be ground so fine that their particles float in the air. Owing to the machinery necessary and to the meagre results in cloud-production, this method has no application to the field. Fluids are capable of being forced by sufficiently high pressure through the narrowest of openings. This method is much used for military purposes. The detonation of an explosive embedded in a substance capable of producing smoke or mist will shatter it to minute particles. This is made use of in gas-shells. As regards condensation methods the use of water for mist-producing is ruled out by reason of its high vapour-pressure and the use of many other substances for the same reason. But there are still more limitations, which leave very few substances suitable as mist—or smoke—producers in the field.

1. The substance must be capable of production in large quantities from the available products of the home country.

2. It must be something that is used in peace as a trade article of the chemical industry, since owing to the masses of it which will be required in war, it would be impossible to stock a year's supply.

3. It must be cheap, otherwise the cost of screening a gun might exceed the cost of the gun itself.

4. It should be powerful, *i.e.*, produce large and thick clouds.

5. It must be non-poisonous, and should cause no harm to one's own troops.

6. In its non-gaseous state it should be as harmless as possible.

7. It should be stable for storing purposes.

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Nothing has yet been found to fulfil these requirements, Nos. 5 and 6 especially are hard to satisfy.

The various mist—or smoke—producers can be conveniently grouped as those which require, and those which do not require, moisture in the atmosphere. Condensation of water on the particles that have been formed without moisture may, however, take place in group 2.

Group 1. (*a*) *SO_3 and its products.* SO_3 is a colourless liquid which boils at 115° Fahr. and evaporates at ordinary temperatures. The presence of water-vapour in the air causes a cloud of fine drops of H_2SO_4 to form. If much water-vapour is present, larger drops are formed, as the H_2SO_4 attracts it. This makes the mist formed by SO_3 much denser in damp air. The pressure of the H_2SO_4 vapour and also of H_2SO_4, H_2O is so low that the cloud formed by SO_3 is very lasting.

SO_3 solution in H_2SO_4, is a trade-article, which gives off fumes strongly in the air. It is more handy in this form but less productive of smoke.

HCl SO_3 may be considered (and is, indeed, formed) as a combination of HCl and SO_3. In the presence of water the HCl and SO_3 fall apart, H_2SO_4 being formed. HCl gas is so hygroscopic that it immediately forms HCl, H_2O. Even concentrated HCl gas has a low pressure so that again the cloud is a lasting one.

(*b*). *Tetrachlorides of Tin, Silicon, etc.* These also form acid-vapour with damp air,

$$SnCl_4 + 4H_2O = Sn(OH)_4 + 4\ HCl.$$

The corresponding hydroxides are delivered in the finest divided state so that the sulphur tri-oxide clouds, which are superior to tetra-chloride clouds in damp air, may be inferior to them if the air is fairly dry.

(*c*). *Phosphorous.* White or yellow phosphorus burns in the air giving off a white smoke, the pent-oxide,

$$P_4 + 5O_2 = 2P_2O_5$$

which is extremely hygroscopic.

$$P_2O_5 + 3H_2O = 2H_3PO_4$$

Like sulphuric acid, phosphoric acid is hygroscopic so that the cloud eventually consists of H_3PO_4, H_2O. As, in this case, oxygen is taken from the atmosphere as well as water-vapour, the effect is greater.

Group 2. To this group belong in the first place all smokes consisting of solid particles. At ordinary temperatures they have generally so low a pressure that the question of evaporation does not arise. Such smoke clouds are the oldest known for military purposes, being made on land by burning damp straw and such substitutes, at sea by checking the draught to the furnaces. Especially, modern war-ships burning oil-fuel can quickly throw out clouds of smoke, consisting of particles of soot and minute drops of water and of unburnt oil.

A thick cloud can also be produced by burning the by-products of the distillation of tar-pitch, anthracene, napthalene, etc. Similar results can be obtained by burning with insufficient draught brickets of these by-products to which have been added straw, saw-dust, peat or brown-coal.

Until smokeless powder replaced gunpowder, battle-fields were covered with combustion products of another kind, viz., the sulphate and carbonate of potassium. Nowadays black powder is burnt for smoke-formation in a mixture with saw-dust, pitch, tallow, etc.

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(*a*) *Berger Mixture.* The essential parts of this are zinc dust and the tetrachloride of carbon, with a proportion of $NaClO_3$ as an oxidiser. Other constituents are Kieselgur, or magnesium carbonate, in order to soak up the liquid CCl_4, and generally NH_4Cl to delay the re-action, which is otherwise very fierce.

Re-action is started by an explosion and the chief constituent of the cloud is the zinc chloride produced. This cloud of course appears in dry air, but is even more effective in damp, since the $ZnCl_2$ is hygroscopic and HCl assists in the cloud-formation.

Berger mixture does not fulfil Condition (5), being very unpleasant to work with. This is possibly due to the formation of small quantities of phosgene.

(*b*). *Tetrachlorides.* The tetrachlorides already shown in Group 1, as needing moist air for the formation of cloud, are included in Group 2 also, since with the aid of ammonia they can be used as cloud-formers in dry air. Especially $SiCl_4$ has thus been much used from aeroplanes, the solid NH_4Cl being formed when $SiCl_4$ and NH_3 are intimately mixed as spray.

Comparative Screening Effects. Gibbs in "Clouds and Smokes" places the order :—(1) Phosphorus ; (2) NH_3+HCl ; (3) $SiCl_4+NH_3+H_2O$; (4) Berger-Mixture ; (5) $SnCl_4+NH_3$; (6) SO_3+NH_3.

Dr. Stampe thinks that in this list the ammonia and hydrochloric acid come too high and the sulphur trioxide too low. He would place SO_3 above Berger-Mixture except in the driest weather. J. Meyer in "Gaskampf" gives a list :—(1) Phosphorus ; (2) SO_3 ; (3) $SnCl_4$; (4) $TiCl_4$.

The discovery of figures, based on experiments and trials, to serve for comparison of the different mists and smokes offers a wide field for scientific investigation.

MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

(*September-October*, 1926).—*The Capture of Belgrade in October*, 1915. After the Austrians were driven out of Serbia in December, 1914, they remained on their southern frontier facing Belgrade on the defensive, until the early autumn of 1915, when German G.H.Q. decided to resume the offensive against Serbia and Montenegro. For this purpose they sent von Mackensen and four Corps. What made such a reinforcement possible was the shortening of the Russian front consequent on the Russian retirement. What made the offensive necessary was the importance of opening up communication between Germany and Turkey, via Austria, Hungary, Serbia (to be eliminated), and Bulgaria (Germany's new ally). It is more than likely that the offensive against Serbia was part of the bargain with Bulgaria.

To Mackensen's Army were added two Austro-Hungarian Corps, and to one of them, the VIIIth Corps, fell the extremely difficult task, and so the honour, of capturing Belgrade. That it was able to do so is due, first and foremost, to the engineers, who for two nights running rowed pontoons

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across the Danube under the Serbian searchlights and every species of fire. More than half the pontoons were lost during the first night, but 3½ battalions were landed and managed to hold on to the foreshore all day. The deficiency of pontoons was made up on the second night by means of country boats, and under the same opposition as before, 3¼ more battalions were carried across. It was this second success that decided the issue, since the infantry were able to get forward and into the city the next afternoon.

One may fairly agree with the author when he writes of what the engineers did, " Only troops animated with the best spirit and excellently trained can carry out such performances. It is in steady, earnest, purposeful work in peace that those foundations are laid which enable the Engineer to conquer with equal honour the enemy and the elements." The story is a thrilling one and the subsequent bridging operations are full of interest.

The Use of Tanks, Aeroplanes and Gas in Mountain-country, by Staff Capt. Angelis. Mountains have always had a considerable influence on the conduct of war. The attacker has always avoided them if possible, while the defender has looked upon them as his allies. Austria is a mountainous country, and Austrians should therefore focus their attention quite specially on mountain-warfare. But the Peace Treaty has disarmed them. Together with heavy artillery it has deprived them of tanks, of aircraft, and of gas, precisely those means which their opponents of yesterday and of to-morrow expect to be decisive in war. It is obvious that mountains must influence the use and effectiveness of all these means.

1. *Tanks.* It is often impossible to use tanks in mountain-country, and at best difficult. Defence against them is very easy. Employment in mass is not possible, but single light tanks, up to 10 tons, might be used with great effect, especially where not expected. Where the use of light tanks is possible all precautions must be taken to defeat them. As good main roads are often found in mountains, armoured cars must also be reckoned with. Here also the defence is easy.

2. *Aeroplanes.* Full and valuable use can be made of aeroplanes in mountains. Their effectiveness is to a certain extent diminished by the more rapid changes of weather there prevailing, and by the lack of aerodromes. On the other hand their work is made easier by the limitations as to movement, quartering and fighting imposed by the mountains on troops working on the ground. In extended mountain regions the lack of suitable landing-grounds may reduce the number of aeroplanes accompanying the forces. A.A. defence is easier because the A.A. artillery can be posted well up the mountains, and so drive the aeroplanes higher still, but more Anti-Aircraft defences will be needed in order to cover all dead ground which might be used for landing places. (*To be concluded*).

The Red Army of the Soviet Union (*continued*). The present law regarding Service for War was accepted by the S.U. Central Executive Committee on 18-9-25. It states that the privilege and right of serving in the fighting branches of the Red Army belongs " to the working classes " only. The non-working classes are put into Labour formations and have to pay a special tax. Besides contractors, merchants, the clergy, etc., there are

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also included in this category farmers who own property and such handicraftsmen as employ others to assist them.

Military service consists of :—

(1). One month's preliminary training in the recruit's 19th year, and one month in his 20th year.

(2). Five years' active service, starting at 21, of which the fighting branches spend three "on unlimited leave," airmen and certain special services, two years, and the navy, one year.

(3). Service in the Army Reserve up to 40 years of age.

The physical state of the recruits leaves much to be desired, the percentage of physically undeveloped and sick far exceeding the figures for 1914. This is ascribed to the long years of war, hunger and want.

The Soviet Government places no great confidence in the peasants, but reckons more on the fidelity of the workmen, who are always sent to those branches which must be specially reliable. Thus, of the 1925 class, 33% of the workmen were sent to the Tanks and Navy, 26% to the Air Force, 20% to Signals, and 21% to the rest of the Army. On the same principles the Government distributes the Communists, who from forming 4 to 8% of all other branches, rise to 12% in the Tanks, 19% in troops for garrison duties in towns, 46% in the Navy and 100% in the Air Force. An important innovation in the Red Army is the admission of women to military service, working women being accepted as volunteers. A certain number of women are serving in the Army, some in the positions of officers, and last year also there were women amongst those who passed through the Military Academy at Moscow. The value of this innovation is yet to be determined. The word 'officer' has been replaced by that of 'commander.' Ranks have been abolished and badges indicate the post a man is holding. There is nothing to prevent a brigadier from taking command of a battalion or even of a company, though it is seldom done. An officer can, however, revert without disgrace. The chief requirement of a candidate who wishes to become an officer is that he should be politically sound. No educational standard is obligatory, and for Infantry and Cavalry Schools little more is required than reading, writing, and the four rules of arithmetic. The age limits are :—Company Chief 33, Battalion Commander 35, Brigade Commander 40, Chief Leaders (Generals), 45.

The objects of getting rid of officers so young are to increase the Reserve and to keep close connection between the Army and the working population, so as to keep an officers' class from coming into existence. It is, however, very noticeable that the Red Army officers imitate the officers of the old Imperial Army and that they keep aloof from the soldiers, although they come from the same class in life.

The pay of the Red Army officers is by far the worst in Europe. A distinctive feature is the appointment of "political leaders" to all units down to companies. They assist the commanders in political affairs. The officers do not care for these political leaders, looking upon them as having insufficient work to justify their positions. Another peculiarity is the Military State Advocate, who plays a great rôle in the Red Army. He is appointed to watch the officers' activities, but assumes a guardianship, which is so noticeable to the soldiers that they

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prefer to make their complaints to the State Advocate instead of to their own officers. (*To be concluded*).

F.A.I.

COAST ARTILLERY JOURNAL.

The Coast Artillery Journal for September, 1926, contains a suggestion that the psychology underlying the term "Anti-Aircraft Defence" is incorrect and promotes a misleading idea of the function of that branch. To avoid the belief, said by the writer to be almost universal amongst the American public, that the Aircraft and Anti-Aircraft Services are antagonistic and are rivals for the biggest helping from the national purse, he suggests that the name of the latter should be changed to the "Sky Defence Service," so as to spread the knowledge that it is a necessary and very efficient helpmate to the Air Service. He argues that as "one gun on land was equal to one ship at sea," it was shown in the last war that "one gun on land was equal to one Zeppelin in the air," and therefore that one satisfactory anti-aircraft gun on land should be nearly equal to an aeroplane in the air, because, no matter how strong, how daring and aggressive an Air Force may be, it cannot prevent incursions by the enemy over some part of the territory which it guards.

In the October number a survey of the History of the French Coast Defences shows how that service was starved by successive rulers and politicians of all tenets, of all ages and on many different occasions, until the imminence of war, each time, necessitated unbalanced expenditure.

Also an article on "Coast Artillery—Fixed or Mobile," asserts that the superiority of land defences over fleets is still considerable. The writer quotes the trouble caused by mobile light batteries in the early days of the Dardanelles fighting, and draws the conclusion that the Artillery in Coast Defence Fortresses should include mobile medium calibres, as well as light, so as to be able to inflict actual damage to ships. Search-lights also to be mobile. Such mobile armament could be used on the land front if necessary. As rails are a source of weakness, cross country traction must be developed for the purpose, with the necessary supports and cramps for ensuring rigidity and stability in action.

The Remington Arms Company are said to have brought out a new priming mixture to be used with rifle cartridges, which eliminates rust, corrosion and barrel pitting. The makers assert that when cartridges containing this new priming mixture are used exclusively, it is not necessary to clean the inside of the barrel at all. The mere use of the mixture renders the ordinary rifle barrel rustless and stainless.

The November number contains a scientific analysis of the Art of Teaching in connection with the Army, or Military Pedagogy as it is called. It concludes with the dictum that "we do not teach unless someone learns," which seems to put the onus on the correct member.

D.M.F.H.

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CORRESPONDENCE.

"NOTES on the CAMPAIGN in FRANCE, 1914."

To the EDITOR, *The R.E. Journal.*

DEAR SIR,—May I be allowed to make clear the point raised by the critic of my 1914 book in your very interesting *R.E. Journal.*

My appreciation was an attempt to show the line of thought which led the French and Germans to act as they did.

The actual plans were as follows:—

The French original plan was:—After concentrating in five Army Areas on a front of 210 miles, to take the offensive with their First and Second Armies south of Metz and with their fifth Army north of Metz. Their Third Army was to form their connecting link between the two attacks. Their Fourth reserve Army was to be ready to strengthen either the right or the left attack. 24 Active Corps (48 Divisions), *plus* 14 reserve Divisions and 10 Cavalry Divisions, were to be available for these operations.

The original German plan was:—(a) To concentrate in seven Army areas on a front of 228 miles on the Western front; 22 Active Corps (44 Divisions) *plus* 28 reserve Divisions and 10 Cavalry Divisions; that is, 72 Divisions and 10 Cavalry Divisions. Twenty-six of the 72 Divisions and five out of the 10 Cavalry Divisions were allotted to the First and Second Armies on a front of 38 miles. (b) To allot to the Russian Front three active corps (6 Divisions), *plus* three Reserve Divisions and one Cavalry Division. (c) To seize Liège by a '*coup-de-main*' if the Belgians refused to allow them a right of way through this town, and to be deployed on the line Strasbourg—Metz—Thionville—Liège—Hassalt by the tenth day of mobilization; twelve days later to reach the line Ghent—Mons—Maubeuge—Mezières—Sedan, and by the thirty-first day of mobilization to be on the line Abbeville—St. Quentin—Metz—Strasbourg; then to continue the wheel of the first five Armies so that the first Army passed west of and south of Paris. (d) Finally, to reinforce the First Army with all available troops so that it could advance east and drive the French Armies against the Jura and Switzerland.

The original plan for the B.E.F., if it arrived, was to land at Boulogne—Havre—Rouen, and to concentrate on the area Maubeuge—Hirson—Le Cateau, with one Cavalry Division, or Cavalry Brigade, and either six or four Divisions, in time to be ready to march from the concentration area on the sixteenth day of mobilization to the left of the line of the French Armies.

The Belgian plan was to utilise Liège and Namur as bridge heads on the Meuse to hinder any enemy from crossing the Meuse from France into Germany or from Germany into France. Her six Divisions and one Cavalry Division were grouped so as to be able to confront quickly, German, French, English or Dutch armies. Antwerp was prepared as a final rallying point for her army.

Yours faithfully,

(*Signed*) A. KEARSEY,

late *Lieut.-Colonel, General Staff.*

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Work of the Royal Engineers in the European War, 1914-1919.

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INFORMATION regarding these educational scholarships may be obtained on application to the Secretary, Institution of Royal Engineers, Chatham. The scholarships are of two kinds: "A," of value not exceeding £55 per annum and tenable between the ages of 10 and 18; and "B," of value not exceeding £20 per annum and tenable between the ages of 11 and 16. The *R.E. War Scholarships* are still restricted to the children or dependents of officers and other ranks of the Royal Engineers who were killed or died of wounds or disease contracted on service, or were permanently disabled, in the Great War. The *R.E. Kitchener Scholarships*, which are unfortunately very few in number, are open to the children or dependents of all officers and other ranks of the Royal Engineers who have either died or been permanently disabled while actually serving.

MONTGOMERIE PRIZE.

ATTENTION is invited to the conditions under which this prize, in value about £10, is offered for competition each year.

1. The Prize is awarded by the Council of the Institution of R.E. in the manner considered best for the encouragement of contributions on professional subjects, by R.E. officers, to the Corps publications. It has been decided that the Prize shall be confined to officers on the Active List not above the rank of Substantive Major

2. The Prize shall consist of (*a*) a book on Survey, Exploration, Travel, Geography, Topography, or Astronomy; the book to be whole-bound in leather, and to have the Montgomerie book-plate with inscription inside; (*b*) the remainder of the year's income of the Fund in cash.

The following are suggested as subjects for contributions:—

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ARTHUR FFOLLIETT GARRETT PRIZE ESSAY, 1927.

Subject selected:—"Railway Work on Active Service."

The Essay should take the form of an appreciation of the Railway position and the railway problems to be met with in the circumstances outlined in the succeeding paras.

In it should be set forth fully the steps that would be taken to cope with the situation; to facilitate prompt construction; and to provide all necessary organization, staff, facilities, plant and stores to carry out construction and to ensure an adequate railway service.

(2). The Expeditionary Force consists of three Divisions and one Cavalry Division, with the normal proportion of non-divisional and L. of C. units, also four Squadrons, R.A.F.

Included in the L. of C. units are:—

One Railway Survey Unit,
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Two Railway Operating Companies,
One Railway Stores Company,
One Advanced Railway Workshops Company,
One Base Railway Workshops Company,
One Railway Telegraph Construction Company.
One Railway Telegraph Operating Station,

also One Dock Company;

all at Small War Establishment and with the several departmental headquarters.

It is probable that the E.F. will be reinforced by one Division.

(3). The Base, which has accommodation for 8 ships at a time and limited facilities for handling loads in excess of 12 tons, is a railway-served port in a friendly country which cannot undertake military operations outside its own borders.

(4). The railway, which is 4ft. 8½in. gauge and single throughout its length, runs 300 miles to the border of the hostile State, against which operations are to be undertaken, and has one 40-mile branch at Mile 30.

(5). The E.F. will require railway communication 450 miles from the coast, *i.e.*, 150 miles into the territory of the hostile State, which is without railways.

(6). The following further railway information and intelligence has been obtained:

i. Railway in friendly State owned and worked by local private Company.

ii. Normal train service:—
2 mixed trains and 4 goods trains per diem, each way, to mileage 200;
1 mixed train and 2 goods trains per diem, each way, between mileage 200 and the terminus at Mile 300;
1 mixed train per diem, each way, on the branch.

iii. Crossing sidings average 10 miles apart.

iv. Line operated on Telegraph and Paper Order System. Home and Outer Home signals at stations.

v. Goods trains maximum loadings:—
270 tons gross, mileage 0—200 and on the branch;
600 tons gross, mileage 200—300.

vi. Rolling Stock:—
70 main line tender engines,
15 shunting engines,
3 10-ton (hand) cranes,
250 30-ton (bogie) trucks,
850 10-ton (four-wheeled) trucks,
80 passenger (bogie) coaches.

vii. 75 lb. rail; wood sleepers, spaced 3ft. centres.

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viii. Ruling grades :—
1/40, mileage 0—200 and on the branch ;
1/100, mileage 200—300.

ix. Fuel, (imported) coal.

x. Water plentiful, but loco. watering plant only sufficient for present train service.

xi. Loco. heavy repair shops at Base.

xii. Engine depots at mileages 0, 100, and 200.

xiii. Reserve of permanent way and other materials small.

xiv. Line poorly ballasted except between mileages 0—100 and 200—250

(7). The enemy only partially trained, but mostly officered by Europeans, and having modern field artillery and aircraft and good anti-aircraft defence, has raided the friendly country for 50 miles and destroyed, or partially destroyed, the railway as far as mileage 250. At this point he is held by the forces of the friendly State, but cavalry raids have been made on the L. of C. as far back as mileage 200. The railway has been restored to mileage 240.

(8). At mileage 260 is a bridge of 8 spans of 100 ft. over a river not more than 200 ft. wide, with a maximum depth of 6ft., except in the flood season, when the river rises as much as 10ft. for short periods and is 600 ft. wide.
There are no other big bridges between mileages 240 and 300, but several small bridges, including some of 40 ft. and 50 ft. span.

(9). Maps of enemy State are inferior.
The country beyond the border of the friendly State is comparatively easy for the first 50 miles; for the next 50 miles it is more broken and gradually rising, probably necessitating some rock cutting and a ruling grade of 1/40 ; beyond this it is again comparatively easy.
There are three rivers to be bridged, one at the border, a mile beyond the terminus at mile 300, and the others at approximately 50 and 100 miles from the border. The rivers are comparatively small streams in the non-flood season, and are not more than 5 ft deep, but are liable to 10 ft floods and are 200 to 300 yards wide when in flood.
There is no surface water except from these three rivers. The villagers obtain their water from wells, but the yields are somewhat precarious except in the flood season.

(10). Operations start from railhead, mileage 240, early in December. The floods generally commence about mid-April and last till the end of June.

(11). The Commander of the E.F. anticipates but little serious resistance and has informed you, his assistant Director of Railways, that this progress will depend on the rapidity with which a railway L. of C. can be constructed and worked. He also informs you that the strength of the R.A.F. with the E.F. is slightly superior to that of the enemy Air Force.

(12). Roads are practically non-existent in the enemy territory, and such as there are will require much attention before even medium M.T. can be used, whilst there is no road metal nor ballast except between mileages 200 and 250 in the friendly State and from 50 to 80 miles from the border in the hostile State.

Essays must reach the office of the Secretary, Institution of R.E., Chatham, not later than the 30th NOVEMBER, 1927. Essays must not be signed but each essay must bear a pseudonym, and the name of the writer, enclosed in a sealed envelope marked with the same pseudonym, must be attached.

The following are the conditions of the Arthur ffolliott Garrett prize :—

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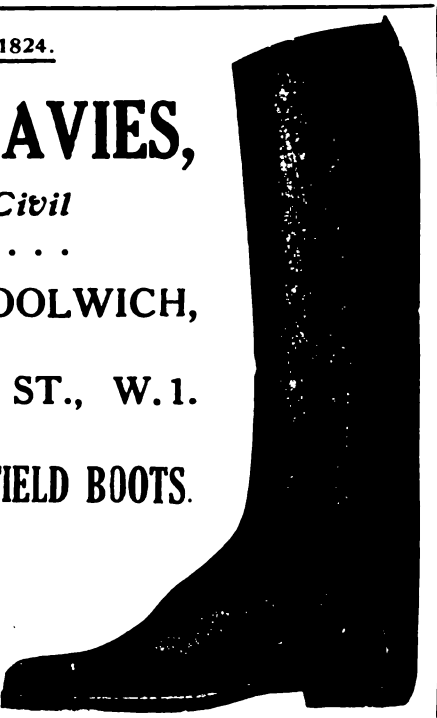

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Some Royal Engineers and Their Work in Africa
Colonel Commandant H. L. Pritchard 193
Co-operation Between R.E. and R.A.F. in and beyond India
Major A. V. Gompertz 217
Survey on Active Service . . . . . Capt. G. F. Heaney 225
Shell Fire v. Permanent Fortification. Liege and Namur
Captain G. E. Grimsdale 237
Mechanicalization of the Army . . . . . Major R. H. Dewing 243
Memorial to Major-General William Roy, F.R.S. 254
Widening a Railway Bridge . . . . . Lieut. R. Gardiner 257
Imperial Wireless . . . . . Colonel F. A. Iles 259
The Shannon Hydro-Electric Power Development . Lieut. J. V. Jenkins 286
A Recent Development in Mechanization . . Major G. Le Q. Martel 295
Battle Honours of Royal Engineer Units 301
Water Divining . . . . Lieut.-Colonel Hugh Rose of Kilravock 315
Pulverised Fuel for Boiler Firing . . . . . Lieut. K. H. Tuson 321
Demolition of a Masonry Bridge . . . . . Captain C. G. Martin 327
Trade Testing and Trade Training . . . Captain R. P. A. D. Lithgow 333
Major-General A. Emmett and Napoleon . . . . . F.E.G.S. 340
Memoir. Colonel S. H. Exham 345
Books. Magazines. Correspondence . . 349

VOL. XLI. No. 2. JUNE, 1927.

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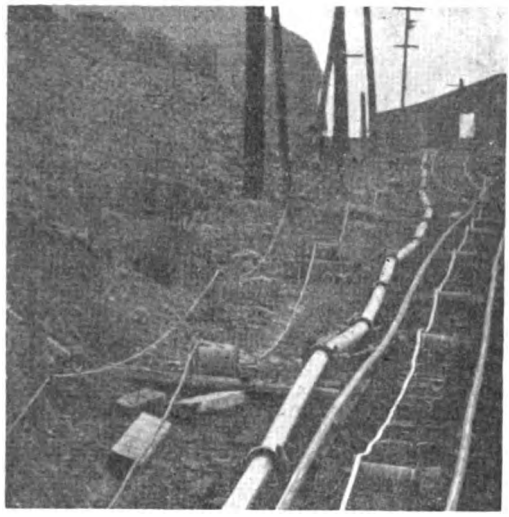

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CONTENTS.

PAGE

1. Some Royal Engineers and their Work in Africa. (*With Map.*) By Col. Commandant H. L. Pritchard, C.B., C.M.G., D.S.O., *A.D.C.*... 194

2. Co-operation Between R.E. and R.A.F. in and Beyond India. By Major A. V. Gompertz, M.C., R.E.... 217

3. Arthur ffolliott Garrett Prize Essay, 1920. Survey on Active Service. By Captain G. F. Heaney, R.E. 225

4. Shell Fire Versus Permanent Fortification. Liège and Namur, 1914. By Captain G. E. Grimsdale, *p.s.c.*, R.E. 237

5. The Effect of Mechanicalization of the Army on the Organisation and Employment of Divisional and Corps Engineers in the Field. By Major R. H. Dewing, D.S.O., M.C., R.E. ... 243

6. Memorial to Major-General William Roy, F.R.S. 254

7. Widening a Railway Bridge. (*With Photos.*) By Lieut. R. Gardiner, R.E. 257

8. Imperial Wireless. (*With Maps.*) By Col. F. A. Iles, C.B.E., D.S.O. R. of O. 259

9. The Shannon Hydro-Electric Power Development. (*With Plates and Photographs.*) By Lieutenant J. V. Jenkins, R.E. 280

10. A Recent Development in Mechanization. By Major G. Le Q. Martel, D.S.O., M.C., R.E. 295

11. Battle Honours of Royal Engineer Units (*continued*) 301

12. Water Divining. By Lt.-Colonel Hugh Rose of Kilravock, C.M.G. (late The Black Watch) 315

13. Pulverised Fuelfor Boiler Firing. (*With Plates.*) By Lieut. K. H. Tuson, R.E. 321

14. Demolition of a Masonry Bridge. (*With Plates and Photographs.*) By Captain C. G. Martin, V.C., D.S.O., R.E. 327

15. Trade Testing and Trade Training. By Capt. R. P. A. D. Lithgow, R.E. 333

16. Major-General A. Emmett and Napoleon. By F.E.G.S. ... 340

17. Memoir 345
Colonel S. H. Exham, C.B., C.B.E., late Royal Engineers. (*With Photograph.*)

18. Books 349
Britain's Sea Soldiers. (By General Sir H. E. Blumberg, K.C.B., Royal Marines.) F.E.G.S.
The World Crisis, 1916-1918. Parts I and II. (By The Rt. Hon. Winston S. Churchill, C.H., M.P.) H.B.-W.
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SOME ROYAL ENGINEERS AND THEIR WORK IN AFRICA.

A Lecture Delivered at Chatham on 24th February, 1927.
By Col. Commandant H. L. Pritchard, C.B., C.M.G., D.S.O., *A.D.C.*

The Lecturer's thanks are due to many R.E. Officers who sent him first hand nformation about the work described in this lecture.

Introduction.

In this lecture I want to describe the great *variety* of the opportunities, the work, and the achievements of some Royal Engineers in Africa during the last thirty to forty years.

That work, and those achievements, have helped in great measure to open up a vast continent, which, forty years ago, was practically closed and unknown.

I have said that I am going to refer to the work of *some* Royal Engineers, because, in a lecture of one hour, it is impossible to deal exhaustively with the work of all the R.E's. who have laboured in Africa, or to name them all.

The Scramble for Africa.

Here we have a map of Africa, which the Survey School kindly prepared for this lecture.

On that map you see the boundaries of the territories of various European nations clearly marked.

But thirty to forty years ago the map of Africa was a very different thing.

Up to that time European nations had in most parts of Africa contented themselves with trading stations on the sea coast, to which the natives from the Hinterland brought their produce to exchange for European goods.

This happy-go-lucky arrangement gave place to what has been called "The Scramble for Africa." The French began it. They started to go into the hinterland of their coastal settlements on the West Coast, making treaties with native chiefs to accept, first, French protection, and then sovereignty.

We soon discovered that unless we did the same thing the French would divert the whole trade in the hinterland of our coastal trading stations to theirs. Consequently we set about securing the allegiance of the tribes behind our settlements.

The Germans were late in joining in the scramble. By the time they took a hand in it the British and French had secured most of

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the best territory, but the Germans elbowed their way in, and we were all engaged in pegging out claims to territory by making treaties with native chiefs.

MILITARY EXPEDITIONS IN WEST AFRICA.

This scramble for Africa somewhat bewildered the native chiefs. Their tribes were nearly always at war with each other, so that many of them welcomed the protection offered by a European Power, and were quick to claim protection when attacked.

Other tribes, however, resented the arrival of the white man, and made war upon him.

These were the causes of numerous military Expeditions, particularly in West Africa, on which the R.E. were well represented.

The expeditions were nearly always organised entirely with West African or West Indian Troops, led by British officers, but in a few cases small bodies of British troops were employed, notably in Lord Wolseley's expedition to Ashanti in 1875, again in the second Ashanti expedition of 1895, and in the suppression of the Ashanti rebellion in 1901.

In West Africa these expeditions travelled usually through dense primeval forest of enormous trees running up to 200 ft. in height, with thick undergrowth and swamps below them, all interlaced with forest creepers. In such forests the sun is never seen, except in village clearings.

To penetrate this forest one must either use native tracks, which become overgrown with extraordinary rapidity directly they fall into disuse, or else one must cut every foot of one's way.

TACTICS OF "BUSH" FIGHTING.

In this sort of country, commonly called "Bush," the tactics of bush fighting do not vary much.

A column on the march has to proceed in single file, all food, and ammunition, and stores, being carried in 50lb loads on the heads of native carriers.

These carriers, though willing to do this duty, have no desire to be involved in fighting, and usually fling down their loads and disappear directly there is any sign of it.

To stop such a single-file column the hostile natives usually built a series of stockades at intervals across the path, and they would construct, and very cleverly camouflage our old friend the "deep military pit," complete with pointed stakes, but they improved upon our specification for this pit, by putting poison on the business end of the pointed stakes.

On either side of the path approaching the stockade, parties would lie in ambush.

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The leading files of the column usually suffered when they came upon these stockades round a bend in the path. It was impossible to march with flank guards laboriously cutting their way through every foot of the forest on either side of the path.

Having, however, found the stockade and ambushes by the system of "trial and error," the normal procedure to overcome the defence was for those who were not thus engaged at a disadvantage in the vanguard, to cut their way into the forest on either side to turn both flanks of ambushes and of stockade.

The defenders usually fled when the flanks were turned. The stockades did not run far to either side of the path. If they did not fly at once the fighting was at any rate on equal terms, in which the white man's leading gained the day.

The stockade then had to be cleared away, or a path cut round it, and the column resumed its march, to repeat the procedure at the next stockade.

Eventually a village would be reached, protected by an extremely strong stockade, often formed of growing trees. Here the R.E. would be called upon to blow a breach.

Lt. W. H. Robinson, R.E., who blew up numerous stockades successfully, was eventually killed at a stockade at a place called Tembé.

R.E. Work on West African Expeditions.

Besides demolitions, the R.E. were required on mapping, telegraph laying, bridging, water supply and hutting.

As maps did not exist, it was the duty of the R.E. to map the route followed by the expedition, by route traverse and sextant observations for latitude. Chronometers were not usually available.

As regards the bridging of rivers for single file traffic, this was done either by the local inhabitants, or by bridging parties of natives marching with the column. The natives were very expert at the work, but it was the business of the R. E. to get them on to it.

The usual method was to cut forked trees at the river bank and use them as the uprights of pile trestles forced by hand into the sandy river bed. The transoms rested in these forks. Roadbearers, also cut at the river bank, were lashed to transoms by creepers torn from the trees and a corduroy roadway similarly lashed on to the roadbearers.

When British troops accompanied the expedition, as in the invasion of Ashanti, the R.E. had more work to do. In the expedition of which Major Sinclair was the C.R.E., the British were not landed until an advance guard of native scouts, organised by Major Baden-Powell, backed by native troops, had penetrated several marches inland.

Behind this screen, hutted camps of bamboo huts were put up for the British at the end of each day's march.

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Split bamboos make an exceedingly comfortable guard bed, and serve to keep the white man off the ground, which is important for health's sake in West Africa. The roofs of the huts were thatched with palm leaves, which were abundant in the forest.

For water supply in these prepared camps for British troops, a boiled and filtered supply was provided entirely from forest materials. Troughs, hollowed out by the natives from tree trunks, water boiled in new earthenware pots, quickly made by the native women, other pots made into filters by the insertion of a sandbag filled with charcoal freshly burnt from forest timber.

The R.E. officers and N.C.O's stationed at Sierra Leone, whose normal duty was the building of coast defences and barracks, almost invariably in the course of their tour of service, came in for one or more of such expeditions as I have been describing, *e.g.*, Mackay, G. H. Boileau (now a Chief Engineer in India), Robinson, who was killed at Tambi; Major General Gwynn, who is now Commandant of the Staff College, began his active service in this way.

Colonel Ellis' Expedition.

Captain Sloggett, R.E., Lt. Gwynn, R.E., and two R.E. N.C.O's, proceeded with Col. Ellis' Expedition to fight the forces of a Chief called Samory, who was harrying tribes under British protection.

The French were also at war with Samory, who had been raiding their territory also.

The French and British Expeditionary Forces, starting from bases widely separated, and moving in dense forest, were unaware of each others' whereabouts, with the unfortunate result that one night they encountered each other. Both forces being under the impression that they were in contact with Samory's tribesmen, a severe action ensued, in which the British Forces suffered heavy casualties, but the French Force was wiped out.

While the respective Foreign Offices in Paris and London were engaged in clearing up this little misunderstanding, Colonel Ellis, although his carriers had bolted, proceeded to his original objective, *i.e.*, Samory's forces, and wiped them out, too.

Lt. Gwynn, who was Intelligence Officer of the Column and commanded the Advance Guard, was severely wounded.

The Fort at Kumassi.

When the second Ashanti expedition took over that country in 1896, Lt. MacInnes, R.E., who was afterwards killed as a Brigadier General in France, built a Fort round the new Residency at Kumassi, which is the Capital of Ashanti.

The R.E. build a lot of forts in various parts of the world, but it is not often that they have the compliment paid to them of a full-dress siege. But MacInnes' fort at Kumassi had to stand a siege of many weeks, and held out successfully.

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In 1901, the Ashantis rose in rebellion, cut communications between Kumassi and the coast, and besieged the Governor of the Gold Coast in Kumassi Fort.

The Ashantis had got into their heads, quite erroneously, that we were trying to find and secure their golden stool. This stool they had hidden when we conquered the country, as it was the throne of their kings, and they believed it contained the soul of their nation.

We were busy with the South African War at the time, but an Expedition had to be organised to march up from the coast and relieve Kumassi; Captain R. S. McClintock, R.E., was a D.A.Q.M.G. of the relieving force. He is now G.S.O., Scottish Command.

Boundary Commissions and Survey.

The scrambling for Africa, of course, led to numerous disputes between European nations concerning the boundaries of their respective territories.

To settle thsee disputes amicably the usual procedure was to set up boundary commissions, on which R.E. officers, on account of their knowledge of survey, were always appointed, and usually an R.E. officer was in charge.

These commissions not only surveyed the boundaries, but were also required to study the whole tribal system of the country and its resources, and deal with administrative and political questions.

After the boundaries had been settled the next task was to survey the vast areas of territory acquired.

It is not possible to give the long list of boundary commissions, or the names of all the R.E. Officers who worked upon them, and who afterwards surveyed the territories, but it is safe to say that wherever you see a boundary of British territory on that map of Africa, there you see the hard work of some Royal Engineers.

About twelve thousand miles of African boundaries were delimited by Royal Engineers.

Conspicuous among these Surveying Officers, at first working in Africa, and later organising and co-ordinating the work of boundary commissions, when he was head of the Survey Branch of the War Office, and afterwards Director General of Ordnance Survey, was Captain C. F. Close, R.E., now Colonel Sir Charles Close.

Among other R.E. Officers employed on this work as subalterns, captains and majors, I will name a few: Kenny, S. C. Grant, Johnstone, O'Shea, Gillam, Woodroffe, Jackson, Watherston, Guggisberg, Gwynn, Maud, G. E. Smith, Whitlock, Austin, Jack, G. C. Williams, and many others.

Major Watherston was Director of Surveys on the Gold Coast, and afterwards was Chief Commissioner of the Northern Territory of that Colony, where he unfortunately died of blackwater fever.

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Some Royal Engineers and Their Work in Africa
Colonel Commandant H. L. Pritchard 193
Co-operation Between R.E. and R.A.F. in and beyond India
Major A. V. Gompertz 217
Survey on Active Service . . . . . Capt. G. F. Heaney 225
Shell Fire v. Permanent Fortification. Liege and Namur
Captain G. E. Grimsdale 237
Mechanicalization of the Army . . . . . Major R. H. Dewing 243
Memorial to Major-General William Roy, F.R.S. 254
Widening a Railway Bridge . . . . . Lieut. R. Gardiner 257
Imperial Wireless . . . . . Colonel F. A. Iles 259
The Shannon Hydro-Electric Power Development . Lieut. J. V. Jenkins 286
A Recent Development in Mechanization . . Major G. Le Q. Martel 295
Battle Honours of Royal Engineer Units 301
Water Divining . . . . Lieut.-Colonel Hugh Rose of Kilravock 315
Pulverised Fuel for Boiler Firing . . . . . Lieut. K. H. Tuson 321
Demolition of a Masonry Bridge . . . . . Captain C. G. Martin 327
Trade Testing and Trade Training . . . Captain R. P. A. D. Lithgow 333
Major-General A. Emmett and Napoleon . . . . . F.E.G.S. 340
Memoir. Colonel S. H. Exham 345
Books. Magazines. Correspondence . . 349

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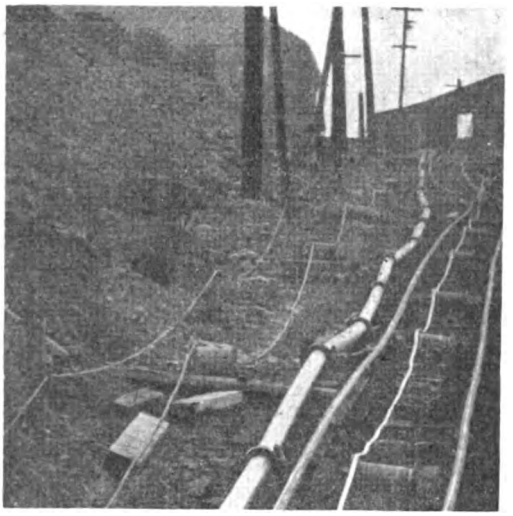

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CONTENTS.

PAGE

1. SOME ROYAL ENGINEERS AND THEIR WORK IN AFRICA. (*With Map.*) By Col. Commandant H. L. Pritchard, C.B., C.M.G., D.S.O., *A.D.C.*... 194

2. CO-OPERATION BETWEEN R.E. AND R.A.F. IN AND BEYOND INDIA. By Major A. V. Gompertz, M.C., R.E.... 217

3. ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1920. Survey on Active Service. By Captain G. F. Heaney, R.E. 225

4. SHELL FIRE VERSUS PERMANENT FORTIFICATION. LIÈGE AND NAMUR, 1914. By Captain G. E. Grimsdale, *p.s.c.*, R.E. 237

5. THE EFFECT OF MECHANICALIZATION OF THE ARMY ON THE ORGANISATION AND EMPLOYMENT OF DIVISIONAL AND CORPS ENGINEERS IN THE FIELD. By Major R. H. Dewing, D.S.O., M.C., R.E. ... 243

6. MEMORIAL TO MAJOR-GENERAL WILLIAM ROY, F.R.S. 254

7. WIDENING A RAILWAY BRIDGE. (*With Photos.*) By Lieut. R. Gardiner, R.E. 257

8. IMPERIAL WIRELESS. (*With Maps.*) By Col. F. A. Iles, C.B.E., D.S.O. R. OF O. 259

9. THE SHANNON HYDRO-ELECTRIC POWER DEVELOPMENT. (*With Plates and Photographs.*) By Lieutenant J. V. Jenkins, R.E. 286

10. A RECENT DEVELOPMENT IN MECHANIZATION. By Major G. Le Q. Martel, D.S.O., M.C., R.E. 295

11. BATTLE HONOURS OF ROYAL ENGINEER UNITS (*continued*) 301

12. WATER DIVINING. By Lt.-Colonel Hugh Rose of Kilravock, C.M.G. (late The Black Watch) 315

13. PULVERISED FUELFOR BOILER FIRING. (*With Plates.*) By Lieut. K. H. Tuson, R.E. 321

14. DEMOLITION OF A MASONRY BRIDGE. (*With Plates and Photographs.*) By Captain C. G. Martin, V.C., D.S.O., R.E. 327

15. TRADE TESTING AND TRADE TRAINING. By Capt. R. P. A. D. Lithgow, R.E. 333

16. MAJOR-GENERAL A. EMMETT AND NAPOLEON. By F.E.G.S. ... 340

17. MEMOIR 345
Colonel S. H. Exham, C.B., C.B.E., late Royal Engineers. (*With Photograph.*)

18. BOOKS 349
Britain's Sea Soldiers. (By General Sir H. E. Blumberg, K.C.B., Royal Marines.) F.E.G.S.
The World Crisis, 1916-1918. Parts I and II. (By The Rt. Hon. Winston S. Churchill, C.H., M.P.) H.B.-W.
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Heerestechnik. F.A.I.

Militarwissenschaftliche und Technische Mitteilungen. F.A.I.

20. CORRESPONDENCE 37

Shell Fire v. Permanent Fortification. Colonel J. C. Matheson (late R.E.) 20th (Field) Company Royal Bombay S. and M. Major M. Rawlence, D.S.O. (late R.E.). Divisional Engineers. Major G. Le Q. Martel, D.S.O., M.C., R.E.

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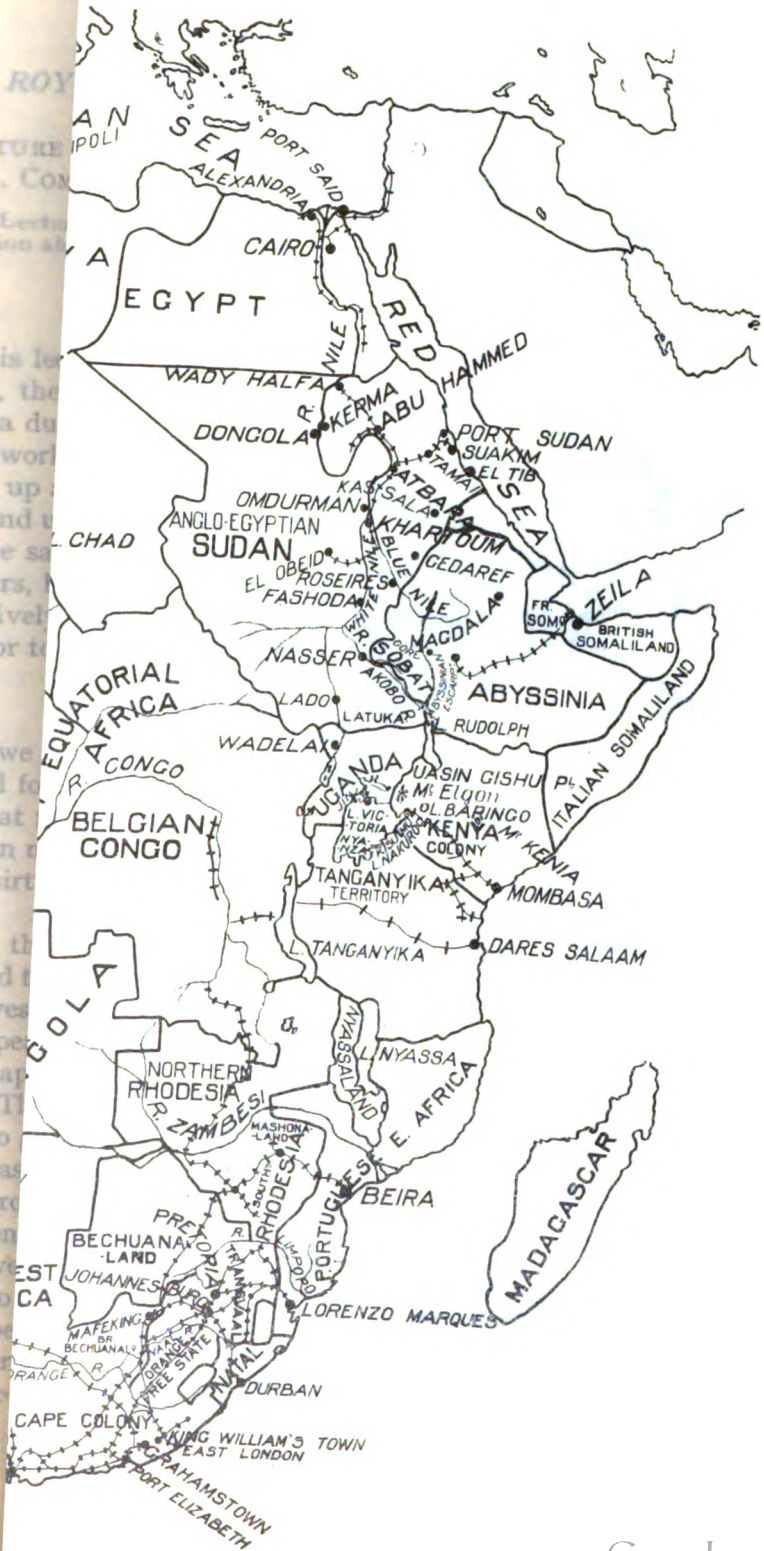

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SOME ROYAL ENGINEERS AND THEIR WORK IN AFRICA.

A LECTURE DELIVERED AT CHATHAM ON 24TH FEBRUARY, 1927.
By COL. COMMANDANT H. L. PRITCHARD, C.B., C.M.G., D.S.O., *A.D.C.*

The Lecturer's thanks are due to many R.E. Officers who sent him first hand nformation about the work described in this lecture.

INTRODUCTION.

In this lecture I want to describe the great *variety* of the opportunities, the work, and the achievements of some Royal Engineers in Africa during the last thirty to forty years.

That work, and those achievements, have helped in great measure to open up a vast continent, which, forty years ago, was practically closed and unknown.

I have said that I am going to refer to the work of *some* Royal Engineers, because, in a lecture of one hour, it is impossible to deal exhaustively with the work of all the R.E's. who have laboured in Africa, or to name them all.

THE SCRAMBLE FOR AFRICA.

Here we have a map of Africa, which the Survey School kindly prepared for this lecture.

On that map you see the boundaries of the territories of various European nations clearly marked.

But thirty to forty years ago the map of Africa was a very different thing.

Up to that time European nations had in most parts of Africa contented themselves with trading stations on the sea coast, to which the natives from the Hinterland brought their produce to exchange for European goods.

This happy-go-lucky arrangement gave place to what has been called "The Scramble for Africa." The French began it. They started to go into the hinterland of their coastal settlements on the West Coast, making treaties with native chiefs to accept, first, French protection, and then sovereignty.

We soon discovered that unless we did the same thing the French would divert the whole trade in the hinterland of our coastal trading stations to theirs. Consequently we set about securing the allegiance of the tribes behind our settlements.

The Germans were late in joining in the scramble. By the time they took a hand in it the British and French had secured most of

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the best territory, but the Germans elbowed their way in, and we were all engaged in pegging out claims to territory by making treaties with native chiefs.

MILITARY EXPEDITIONS IN WEST AFRICA.

This scramble for Africa somewhat bewildered the native chiefs. Their tribes were nearly always at war with each other, so that many of them welcomed the protection offered by a European Power, and were quick to claim protection when attacked.

Other tribes, however, resented the arrival of the white man, and made war upon him.

These were the causes of numerous military Expeditions, particularly in West Africa, on which the R.E. were well represented.

The expeditions were nearly always organised entirely with West African or West Indian Troops, led by British officers, but in a few cases small bodies of British troops were employed, notably in Lord Wolseley's expedition to Ashanti in 1875, again in the second Ashanti expedition of 1895, and in the suppression of the Ashanti rebellion in 1901.

In West Africa these expeditions travelled usually through dense primeval forest of enormous trees running up to 200 ft. in height, with thick undergrowth and swamps below them, all interlaced with forest creepers. In such forests the sun is never seen, except in village clearings.

To penetrate this forest one must either use native tracks, which become overgrown with extraordinary rapidity directly they fall into disuse, or else one must cut every foot of one's way.

TACTICS OF "BUSH" FIGHTING.

In this sort of country, commonly called "Bush," the tactics of bush fighting do not vary much.

A column on the march has to proceed in single file, all food, and ammunition, and stores, being carried in 50lb loads on the heads of native carriers.

These carriers, though willing to do this duty, have no desire to be involved in fighting, and usually fling down their loads and disappear directly there is any sign of it.

To stop such a single-file column the hostile natives usually built a series of stockades at intervals across the path, and they would construct, and very cleverly camouflage our old friend the "deep military pit," complete with pointed stakes, but they improved upon our specification for this pit, by putting poison on the business end of the pointed stakes.

On either side of the path approaching the stockade, parties would lie in ambush.

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The leading files of the column usually suffered when they came upon these stockades round a bend in the path. It was impossible to march with flank guards laboriously cutting their way through every foot of the forest on either side of the path.

Having, however, found the stockade and ambushes by the system of "trial and error," the normal procedure to overcome the defence was for those who were not thus engaged at a disadvantage in the vanguard, to cut their way into the forest on either side to turn both flanks of ambushes and of stockade.

The defenders usually fled when the flanks were turned. The stockades did not run far to either side of the path. If they did not fly at once the fighting was at any rate on equal terms, in which the white man's leading gained the day.

The stockade then had to be cleared away, or a path cut round it, and the column resumed its march, to repeat the procedure at the next stockade.

Eventually a village would be reached, protected by an extremely strong stockade, often formed of growing trees. Here the R.E. would be called upon to blow a breach.

Lt. W. H. Robinson, R.E., who blew up numerous stockades successfully, was eventually killed at a stockade at a place called Tembé.

R.E. Work on West African Expeditions.

Besides demolitions, the R.E. were required on mapping, telegraph laying, bridging, water supply and hutting.

As maps did not exist, it was the duty of the R.E. to map the route followed by the expedition, by route traverse and sextant observations for latitude. Chronometers were not usually available.

As regards the bridging of rivers for single file traffic, this was done either by the local inhabitants, or by bridging parties of natives marching with the column. The natives were very expert at the work, but it was the business of the R. E. to get them on to it.

The usual method was to cut forked trees at the river bank and use them as the uprights of pile trestles forced by hand into the sandy river bed. The transoms rested in these forks. Roadbearers, also cut at the river bank, were lashed to transoms by creepers torn from the trees and a corduroy roadway similarly lashed on to the roadbearers.

When British troops accompanied the expedition, as in the invasion of Ashanti, the R.E. had more work to do. In the expedition of which Major Sinclair was the C.R.E., the British were not landed until an advance guard of native scouts, organised by Major Baden-Powell, backed by native troops, had penetrated several marches inland.

Behind this screen, hutted camps of bamboo huts were put up for the British at the end of each day's march.

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Split bamboos make an exceedingly comfortable guard bed, and serve to keep the white man off the ground, which is important for health's sake in West Africa. The roofs of the huts were thatched with palm leaves, which were abundant in the forest.

For water supply in these prepared camps for British troops, a boiled and filtered supply was provided entirely from forest materials. Troughs, hollowed out by the natives from tree trunks, water boiled in new earthenware pots, quickly made by the native women, other pots made into filters by the insertion of a sandbag filled with charcoal freshly burnt from forest timber.

The R.E. officers and N.C.O's stationed at Sierra Leone, whose normal duty was the building of coast defences and barracks, almost invariably in the course of their tour of service, came in for one or more of such expeditions as I have been describing, *e.g.*, Mackay, G. H. Boileau (now a Chief Engineer in India), Robinson, who was killed at Tambi; Major General Gwynn, who is now Commandant of the Staff College, began his active service in this way.

Colonel Ellis' Expedition.

Captain Sloggett, R.E., Lt. Gwynn, R.E., and two R.E. N.C.O's, proceeded with Col. Ellis' Expedition to fight the forces of a Chief called Samory, who was harrying tribes under British protection.

The French were also at war with Samory, who had been raiding their territory also.

The French and British Expeditionary Forces, starting from bases widely separated, and moving in dense forest, were unaware of each others' whereabouts, with the unfortunate result that one night they encountered each other. Both forces being under the impression that they were in contact with Samory's tribesmen, a severe action ensued, in which the British Forces suffered heavy casualties, but the French Force was wiped out.

While the respective Foreign Offices in Paris and London were engaged in clearing up this little misunderstanding, Colonel Ellis, although his carriers had bolted, proceeded to his original objective, *i.e.*, Samory's forces, and wiped them out, too.

Lt. Gwynn, who was Intelligence Officer of the Column and commanded the Advance Guard, was severely wounded.

The Fort at Kumassi.

When the second Ashanti expedition took over that country in 1896, Lt. MacInnes, R.E., who was afterwards killed as a Brigadier General in France, built a Fort round the new Residency at Kumassi, which is the Capital of Ashanti.

The R.E. build a lot of forts in various parts of the world, but it is not often that they have the compliment paid to them of a full-dress siege. But MacInnes' fort at Kumassi had to stand a siege of many weeks, and held out successfully.

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In 1901, the Ashantis rose in rebellion, cut communications between Kumassi and the coast, and besieged the Governor of the Gold Coast in Kumassi Fort.

The Ashantis had got into their heads, quite erroneously, that we were trying to find and secure their golden stool. This stool they had hidden when we conquered the country, as it was the throne of their kings, and they believed it contained the soul of their nation.

We were busy with the South African War at the time, but an Expedition had to be organised to march up from the coast and relieve Kumassi; Captain R. S. McClintock, R.E., was a D.A.Q.M.G. of the relieving force. He is now G.S.O., Scottish Command.

Boundary Commissions and Survey.

The scrambling for Africa, of course, led to numerous disputes between European nations concerning the boundaries of their respective territories.

To settle thsee disputes amicably the usual procedure was to set up boundary commissions, on which R.E. officers, on account of their knowledge of survey, were always appointed, and usually an R.E. officer was in charge.

These commissions not only surveyed the boundaries, but were also required to study the whole tribal system of the country and its resources, and deal with administrative and political questions.

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It is not possible to give the long list of boundary commissions, or the names of all the R.E. Officers who worked upon them, and who afterwards surveyed the territories, but it is safe to say that wherever you see a boundary of British territory on that map of Africa, there you see the hard work of some Royal Engineers.

About twelve thousand miles of African boundaries were delimited by Royal Engineers.

Conspicuous among these Surveying Officers, at first working in Africa, and later organising and co-ordinating the work of boundary commissions, when he was head of the Survey Branch of the War Office, and afterwards Director General of Ordnance Survey, was Captain C. F. Close, R.E., now Colonel Sir Charles Close.

Among other R.E. Officers employed on this work as subalterns, captains and majors, I will name a few: Kenny, S. C. Grant, Johnstone, O'Shea, Gillam, Woodroffe, Jackson, Watherston, Guggisberg, Gwynn, Maud, G. E. Smith, Whitlock, Austin, Jack, G. C. Williams, and many others.

Major Watherston was Director of Surveys on the Gold Coast, and afterwards was Chief Commissioner of the Northern Territory of that Colony, where he unfortunately died of blackwater fever.

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THE INSTITUTION OF ROYAL ENGINEERS.

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CONTENTS.

		PAGE
1.	SOME ROYAL ENGINEERS AND THEIR WORK IN AFRICA. (*With Map.*) By Col. Commandant H. L. Pritchard, C.B., C.M.G., D.S.O., *A.D.C.*...	194
2.	CO-OPERATION BETWEEN R.E. AND R.A.F. IN AND BEYOND INDIA. By Major A. V. Gompertz, M.C., R.E....	217
3.	ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1926. Survey on Active Service. By Captain G. F. Heaney, R.E.	225
4.	SHELL FIRE VERSUS PERMANENT FORTIFICATION. LIÈGE AND NAMUR, 1914. By Captain G. E. Grimsdale, *p.s.c.*, R.E.	237
5.	THE EFFECT OF MECHANICALIZATION OF THE ARMY ON THE ORGANISATION AND EMPLOYMENT OF DIVISIONAL AND CORPS ENGINEERS IN THE FIELD. By Major R. H. Dewing, D.S.O., M.C., R.E. ...	243
6.	MEMORIAL TO MAJOR-GENERAL WILLIAM ROY, F.R.S.	254
7.	WIDENING A RAILWAY BRIDGE. (*With Photos.*) By Lieut. R. Gardiner, R.E.	257
8.	IMPERIAL WIRELESS. (*With Maps.*) By Col. F. A. Iles, C.B.E., D.S.O. R. OF O.	259
9.	THE SHANNON HYDRO-ELECTRIC POWER DEVELOPMENT. (*With Plates and Photographs.*) By Lieutenant J. V. Jenkins, R.E.	286
10.	A RECENT DEVELOPMENT IN MECHANIZATION. By Major G. Le Q. Martel, D.S.O., M.C., R.E.	295
11.	BATTLE HONOURS OF ROYAL ENGINEER UNITS (*continued*)	301
12.	WATER DIVINING. By Lt.-Colonel Hugh Rose of Kilravock, C.M.G. (late The Black Watch)	315
13.	PULVERISED FUELFOR BOILER FIRING. (*With Plates.*) By Lieut. K. H. Tuson, R.E.	321
14.	DEMOLITION OF A MASONRY BRIDGE. (*With Plates and Photographs.*) By Captain C. G. Martin, V.C., D.S.O., R.E.	327
15.	TRADE TESTING AND TRADE TRAINING. By Capt. R. P. A. D. Lithgow, R.E.	333
16.	MAJOR-GENERAL A. EMMETT AND NAPOLEON. By F.E.G.S. ...	340
17.	MEMOIR ... ... Colonel S. H. Exham, C.B., C.B.E., late Royal Engineers. (*With Photograph.*)	345
18.	BOOKS ... ... Britain's Sea Soldiers. (By General Sir H. E. Blumberg, K.C.B., Royal Marines.) F.E.G.S. The World Crisis, 1916-1918. Parts I and II. (By The Rt. Hon. Winston S. Churchill, C.H., M.P.) H.B.-W. Governments and War, (By Major-General Sir F. Maurice, K.C.M.G., C.B.,) H.B.-W.	349

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BOOKS—(*continued*)—

Imperial Defence. (By S. King-Hall.) D.M.F.H.

Tactical Schemes. (By Lt.-Col. A. Kearsey, D.S.O., O.B.E., *p.s.c.*) N.W.N.-C.

Ordinary Differential Equations. (By E. L. Ince.) Lieut.-Col. J. M. Wade, B.SC. (late R.E.)

Practical Physics. (By T. J. Bedford, M.A., F.INST.P.) R.M.

Mechanics Applied to Engineering. (By John Goodman, WH.SCH., M.INST.C.E.) R.M.

"Colas" Roads. G.B.O.T.

Some Books on Heating. W.B.B.

19. MAGAZINES .. .. 3[illegible]

Revue Militaire Francaise. H.A.J.P.

Revue du Genie.

Bulletin Belge des Sciences Militaires. W.A.J.O'M.

Heerestechnik. F.A.I.

Militarwissenschaftliche und Technische Mitteilungen. F.A.I.

20. CORRESPONDENCE ... ... 37[illegible]

Shell Fire v. Permanent Fortification. Colonel J. C. Matheson (late R.E.) 20th (Field) Company Royal Bombay S. and M. Major M. Rawlence, D.S.O. (late R.E.). Divisional Engineers. Major G. Le Q. Martel, D.S.O., M.C., R.E.

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ND THEIR WORK IN AFRICA.

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SOME ROYAL ENGINEERS AND THEIR WORK IN AFRICA.

A LECTURE DELIVERED AT CHATHAM ON 24TH FEBRUARY, 1927.
By COL. COMMANDANT H. L. PRITCHARD, C.B., C.M.G., D.S.O., *A.D.C.*

The Lecturer's thanks are due to many R.E. Officers who sent him first hand nformation about the work described in this lecture.

INTRODUCTION.

In this lecture I want to describe the great *variety* of the opportunities, the work, and the achievements of some Royal Engineers in Africa during the last thirty to forty years.

That work, and those achievements, have helped in great measure to open up a vast continent, which, forty years ago, was practically closed and unknown.

I have said that I am going to refer to the work of *some* Royal Engineers, because, in a lecture of one hour, it is impossible to deal exhaustively with the work of all the R.E's. who have laboured in Africa, or to name them all.

THE SCRAMBLE FOR AFRICA.

Here we have a map of Africa, which the Survey School kindly prepared for this lecture.

On that map you see the boundaries of the territories of various European nations clearly marked.

But thirty to forty years ago the map of Africa was a very different thing.

Up to that time European nations had in most parts of Africa contented themselves with trading stations on the sea coast, to which the natives from the Hinterland brought their produce to exchange for European goods.

This happy-go-lucky arrangement gave place to what has been called "The Scramble for Africa." The French began it. They started to go into the hinterland of their coastal settlements on the West Coast, making treaties with native chiefs to accept, first, French protection, and then sovereignty.

We soon discovered that unless we did the same thing the French would divert the whole trade in the hinterland of our coastal trading stations to theirs. Consequently we set about securing the allegiance of the tribes behind our settlements.

The Germans were late in joining in the scramble. By the time they took a hand in it the British and French had secured most of

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the best territory, but the Germans elbowed their way in, and we were all engaged in pegging out claims to territory by making treaties with native chiefs.

MILITARY EXPEDITIONS IN WEST AFRICA.

This scramble for Africa somewhat bewildered the native chiefs. Their tribes were nearly always at war with each other, so that many of them welcomed the protection offered by a European Power, and were quick to claim protection when attacked.

Other tribes, however, resented the arrival of the white man, and made war upon him.

These were the causes of numerous military Expeditions, particularly in West Africa, on which the R.E. were well represented.

The expeditions were nearly always organised entirely with West African or West Indian Troops, led by British officers, but in a few cases small bodies of British troops were employed, notably in Lord Wolseley's expedition to Ashanti in 1875, again in the second Ashanti expedition of 1895, and in the suppression of the Ashanti rebellion in 1901.

In West Africa these expeditions travelled usually through dense primeval forest of enormous trees running up to 200 ft. in height, with thick undergrowth and swamps below them, all interlaced with forest creepers. In such forests the sun is never seen, except in village clearings.

To penetrate this forest one must either use native tracks, which become overgrown with extraordinary rapidity directly they fall into disuse, or else one must cut every foot of one's way.

TACTICS OF "BUSH" FIGHTING.

In this sort of country, commonly called "Bush," the tactics of bush fighting do not vary much.

A column on the march has to proceed in single file, all food, and ammunition, and stores, being carried in 50lb loads on the heads of native carriers.

These carriers, though willing to do this duty, have no desire to be involved in fighting, and usually fling down their loads and disappear directly there is any sign of it.

To stop such a single-file column the hostile natives usually built a series of stockades at intervals across the path, and they would construct, and very cleverly camouflage our old friend the "deep military pit," complete with pointed stakes, but they improved upon our specification for this pit, by putting poison on the business end of the pointed stakes.

On either side of the path approaching the stockade, parties would lie in ambush.

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The leading files of the column usually suffered when they came upon these stockades round a bend in the path. It was impossible to march with flank guards laboriously cutting their way through every foot of the forest on either side of the path.

Having, however, found the stockade and ambushes by the system of "trial and error," the normal procedure to overcome the defence was for those who were not thus engaged at a disadvantage in the vanguard, to cut their way into the forest on either side to turn both flanks of ambushes and of stockade.

The defenders usually fled when the flanks were turned. The stockades did not run far to either side of the path. If they did not fly at once the fighting was at any rate on equal terms, in which the white man's leading gained the day.

The stockade then had to be cleared away, or a path cut round it, and the column resumed its march, to repeat the procedure at the next stockade.

Eventually a village would be reached, protected by an extremely strong stockade, often formed of growing trees. Here the R.E. would be called upon to blow a breach.

Lt. W. H. Robinson, R.E., who blew up numerous stockades successfully, was eventually killed at a stockade at a place called Tembé.

R.E. Work on West African Expeditions.

Besides demolitions, the R.E. were required on mapping, telegraph laying, bridging, water supply and hutting.

As maps did not exist, it was the duty of the R.E. to map the route followed by the expedition, by route traverse and sextant observations for latitude. Chronometers were not usually available.

As regards the bridging of rivers for single file traffic, this was done either by the local inhabitants, or by bridging parties of natives marching with the column. The natives were very expert at the work, but it was the business of the R. E. to get them on to it.

The usual method was to cut forked trees at the river bank and use them as the uprights of pile trestles forced by hand into the sandy river bed. The transoms rested in these forks. Roadbearers, also cut at the river bank, were lashed to transoms by creepers torn from the trees and a corduroy roadway similarly lashed on to the roadbearers.

When British troops accompanied the expedition, as in the invasion of Ashanti, the R.E. had more work to do. In the expedition of which Major Sinclair was the C.R.E., the British were not landed until an advance guard of native scouts, organised by Major Baden-Powell, backed by native troops, had penetrated several marches inland.

Behind this screen, hutted camps of bamboo huts were put up for the British at the end of each day's march.

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Split bamboos make an exceedingly comfortable guard bed, and serve to keep the white man off the ground, which is important for health's sake in West Africa. The roofs of the huts were thatched with palm leaves, which were abundant in the forest.

For water supply in these prepared camps for British troops, a boiled and filtered supply was provided entirely from forest materials. Troughs, hollowed out by the natives from tree trunks, water boiled in new earthenware pots, quickly made by the native women, other pots made into filters by the insertion of a sandbag filled with charcoal freshly burnt from forest timber.

The R.E. officers and N.C.O's stationed at Sierra Leone, whose normal duty was the building of coast defences and barracks, almost invariably in the course of their tour of service, came in for one or more of such expeditions as I have been describing, *e.g.*, Mackay, G. H. Boileau (now a Chief Engineer in India), Robinson, who was killed at Tambi; Major General Gwynn, who is now Commandant of the Staff College, began his active service in this way.

COLONEL ELLIS' EXPEDITION.

Captain Sloggett, R.E., Lt. Gwynn, R.E., and two R.E. N.C.O's, proceeded with Col. Ellis' Expedition to fight the forces of a Chief called Samory, who was harrying tribes under British protection.

The French were also at war with Samory, who had been raiding their territory also.

The French and British Expeditionary Forces, starting from bases widely separated, and moving in dense forest, were unaware of each others' whereabouts, with the unfortunate result that one night they encountered each other. Both forces being under the impression that they were in contact with Samory's tribesmen, a severe action ensued, in which the British Forces suffered heavy casualties, but the French Force was wiped out.

While the respective Foreign Offices in Paris and London were engaged in clearing up this little misunderstanding, Colonel Ellis, although his carriers had bolted, proceeded to his original objective, *i.e.*, Samory's forces, and wiped them out, too.

Lt. Gwynn, who was Intelligence Officer of the Column and commanded the Advance Guard, was severely wounded.

THE FORT AT KUMASSI.

When the second Ashanti expedition took over that country in 1896, Lt. MacInnes, R.E., who was afterwards killed as a Brigadier General in France, built a Fort round the new Residency at Kumassi, which is the Capital of Ashanti.

The R.E. build a lot of forts in various parts of the world, but it is not often that they have the compliment paid to them of a full-dress siege. But MacInnes' fort at Kumassi had to stand a siege of many weeks, and held out successfully.

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In 1901, the Ashantis rose in rebellion, cut communications between Kumassi and the coast, and besieged the Governor of the Gold Coast in Kumassi Fort.

The Ashantis had got into their heads, quite erroneously, that we were trying to find and secure their golden stool. This stool they had hidden when we conquered the country, as it was the throne of their kings, and they believed it contained the soul of their nation.

We were busy with the South African War at the time, but an Expedition had to be organised to march up from the coast and relieve Kumassi; Captain R. S. McClintock, R.E., was a D.A.Q.M.G. of the relieving force. He is now G.S.O., Scottish Command.

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Major Watherston was Director of Surveys on the Gold Coast, and afterwards was Chief Commissioner of the Northern Territory of that Colony, where he unfortunately died of blackwater fever.

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Major Guggisberg, after surveying in Gold Coast Colony, was Surveyor-General of Nigeria, with Waterhouse and Bulkeley working under him. He is now Governor of the Gold Coast.

Colonel W. G. Morris carried out the geodetic triangulation of South Africa, based on which L. C. Jackson and Winterbotham completed the survey of the Orange Free State.

In the Sudan the Survey Department was created by Colonel the Hon. M. G. Talbot, who was succeeded by Lt.-Col. Pearson, who worked for many years surveying the Sudan, and died there just as he was about to retire.

In Lower Egypt, Capt. Lyons, R.E., (now Sir Henry) was Director of Survey, Geology and Archæology. He is recognised as one of the greatest authorities on Egyptian Archæology.

One would have to continue for a very long time if one were to attempt to give a complete account of the survey work done in Africa by Royal Engineers.

It carried them as explorers over vast areas of an unknown country that had never seen a white man before.

It gave them unrivalled opportunities for big game shooting. In fact, when G. E. Smith (better known as "Uganda Smith") first returned from British East Africa with his stories of the vast herds of every kind of big game roaming the country, his reputation for veracity was severely tried, but has since been amply vindicated.

The work led them into positions in the administration of the territories acquired. Frequently they broke off their work to take part in military operations.

Lt. Foulkes and the Emir of Kano.

For instance, when Major McD. Elliott, R.E., was in charge of the boundary commission, delimiting the Anglo-French boundary of Northern Nigeria, Sir Frederick Lugard, Governor of Nigeria, found it necessary to dispatch an expedition which was first to capture Kano, and then proceed against the Sultan of Sokoto.

Kano was captured, but the Emir of Kano escaped, and was likely to raise the tribes on the flank of the expedition when it marched on Sokoto.

Lt. Foulkes and Lt. Frith were working under Major McD. Elliott, and at that time Lt. Foulkes (who is now Chief Engineer Aldershot Command), was working detached some distance north-east of Sokoto, on the edge of the Sahara Desert. He had an escort of fourteen Hausa soldiers. No doubt the size of his small force was much exaggerated by native rumour, with the result that friendly natives near Gober, where the Emir of Kano was sheltering, sent word to Lt. Foulkes that the King of Gober was likely to side with the British, and that if Foulkes would support him with his force, he would probably hand over the Emir of Kano.

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On receipt of this information Foulkes, who had previously taken part in several West African Expeditions, mounted his servant, and a corporal, and four Hausa soldiers, on country ponies, and rode continuously for 53 hours without resting, except to water and feed the ponies. Having thus covered 175 miles, he arrived at the walled town of Gober with his servant and the Corporal. The other four had been unable to keep up.

Foulkes decided to bluff. He interviewed the King of Gober, stated he had a large force in the neighbourhood, and demanded that the Emir of Kano should be handed over to him. The King of Gober was bluffed, and handed over the Emir, whom Foulkes forthwith hustled off and delivered to Sir F. Lugard, with the result that the Expedition was not troubled by the Emir's people in the march to Sokoto.

Development of West Africa.

The survey work which has been described, of course, facilitated the development of newly acquired territories, and in this development work the R.E. played a considerable part.

The Governorship of the Gold Coast Colony has become almost a perquisite of the R.E. As Governors we have provided Sir Henry Macallum, Sir Matthew Nathan and Sir Gordon Guggisberg.

When Sir M. Nathan was Governor of the Gold Coast Colony, from 1900-1904, he caused the first railway to be built in West Africa. He found the mining concessions in chaos. For the survey of these concessions he secured Captain Watherston, R.E., with some other officers and several R.E. N.C.O's. Their valuable surveys gradually evolved order out of chaos in the concessions.

Guggisberg succeeded Watherston, and E. F. W. Lees took over from Guggisberg. C. B. O. Symons and King were among the officers thus employed.

Major Sir M. Nathan has since held several very important Government appointments, *e.g.*, Governor of Natal, and then of Hong Kong, Permanent Under Secretary of State for Ireland, and has only recently returned from being Governor of Queensland.

Watherston and Guggisberg many years ago selected a site at Takeradi Bay, where they were confident a deep water harbour could be built, but they were up against vested interests at existing landing places, and could get no backing for their scheme.

Now, however, that Sir Gordon Guggisberg is Governor of the Gold Coast, he has caused the Takaradi harbour scheme to be put in hand, and it is approaching completion. Harbour work on the West Coast of Africa is uncertain work. There is always the possibility of sand silting up, but, if the scheme proves a success, and if it becomes possible for large ships to lie alongside permanent deep water quays, Sir G. Guggisberg will have conferred a great boon on the Colony, which must increase its prosperity vastly.

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Up to now, all goods have been landed in lighters and passengers in surf boats, from which they are carried ashore on the backs of natives. They embark in the same way.

Getting on to the gangway of a steamer from a surf boat can be quite an exciting experience. I once had to assist a drunken man to perform this feat. It would have been all right if he had been drunk enough to be treated like a sack of potatoes to be flung on the gangway, but unfortunately he was not. He had his own ideas as to the right moment to jump for the gangway, and the moments he selected were not the right ones.

Sir Gordon Guggisberg's Governership of the Gold Coast has been remarkable for the progress made by the Colony in that period. The mileage of motor roads has increased from 1,300 to 4,000, and of railways by 250 miles. The result is apparent in the trade and revenue. For instance, revenue has increased from 1½ millions to four millions per annum, and the bank balance from £160,000 to three millions.

Major W. E. Lees, R.E., was Director of Public Works in the Gold Coast and Northern Territories from 1904-10. As such he was responsible for the construction and maintenance of roads and building works, excluding railways and harbours.

These works included the water supply of two large towns, Accra and Sekondi, costing 1¼ millions each, town planning, Government buildings for Hospitals, Court-houses, Post-offices, Schools, Prisons, Lunatic Asylums, Police Barracks, etc.

In 1909 a special roads branch was formed under Major Leslie, R.E., with other R.E. officers under him. To-day, R.E. officers are employed on this work.

As a result of all the work that has been referred to, one can nowadays travel in West Africa by rail and road for many thousands of miles where formerly one had to walk every yard, as horses cannot live within many marches of the coast.

The most rapid mode of travel used to be in a hammock, slung fore and aft on cross bars, which rested on the heads of four natives striding along.

There was one R.E. subaltern who, when he landed in West Africa, weighed 18 stone. When the natives who were detailed to carry him in a hammock saw him they fled into the "bush," so he had to walk everywhere. Walking in West Africa is very good for the figure, but I am afraid it was not a permanent cure, as I am told that he now weighs 22 stone.

NIGERIA.

SIR GEORGE TAUBMAN-GOLDIE.

We will now travel on to Nigeria, and here we come across a very remarkable man who began his career in the Corps.

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It is entirely due to Sir George Taubman-Goldie that the enormous territory known as Nigeria belongs to the British Empire. It is an exceedingly valuable possession with great possibilities for development.

Sir G. Taubman-Goldie revived the method of Government by Chartered Company, on the precedent of the old East India Company, and Rhodes was copying Taubman-Goldie when he applied the same system to Rhodesia. Sir William Mackinnon, in East Africa, was also inspired by Taubman-Goldie's example.

It was in 1877 that he first visited the Niger Country, and by 1879 he had amalgamated all the British trading concerns on the Niger into a single company called the British Niger Company. In 1881, he applied for a charter for the company which, when granted in 1886, gave the company practically sovereign powers.

Several French trading companies were competing keenly on the Niger, but the British Company bought them out. At the same time, Goldie concluded over 400 political treaties with tribal chiefs who accepted British sovereignty.

The Germans next appeared upon the scene, and, strongly backed by Bismarck, tried to compete both in trading and in political ascendancy.

Protracted negotiations ensued with both Germany and France, throughout which Goldie was the constant adviser and watchdog alongside Lord Salisbury at the Foreign Office, and Mr. Joseph Chamberlain at the Colonial Office, and it was not till 1898 that an agreement was signed with both France and Germany which secured Nigeria to Great Britain.

Goldie governed the affairs of Nigeria from the London offices of the Niger Company which, unlike some other Chartered Companies, paid a good dividend. On January 1st, 1900, the administration of Nigeria was taken over by the Imperial Government.

In 1903-4, Goldie, at the request of the British South Africa Company, visited Rhodesia, and drew up the first scheme for the self-government of that country.

Sir Percy Girouard as Governor of Nigeria.

The next prominent Royal Engineer to whose work in Nigeria I would refer, is Sir Percy Girouard, first as High Commissioner of Northern Nigeria, and later as Governor of the whole Colony.

It was during his vigorous administration that great progress was made in developing the country, and it was entirely due to him that a great stride forward was taken in railway development by the construction of that important and economically successful line, the Baro-Kano Railway.

The Baro-Kano Railway.

This railway was mainly constructed by Royal Engineers under the

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general supervision of Mr. Eaglesome, who was Director of Railways and Public Works in Nigeria.

As you see from the map, the railway starts from Baro about 400 miles up the river Niger, to which boats with four feet draught can navigate all the year round, and runs for about 300 miles up to Kano, in Northern Nigeria, opening up a country specially suitable for cotton growing, and rich in tin. Of course, the railway facilitates the administration and development of the country. Previous to its construction all goods were transported on the heads of native carriers. The railway had been projected, and much desired, for some years before it was built, but the estimated cost had made it prohibitive. The original survey was for a railway with 1/50 ruling gradient. When Girouard arrived in Nigeria he examined the proposed route of the railway himself, and selected a better one with a ruling gradient of only 1/143 up and 1/166 down. Moreover, he guaranteed to build it for £3,000 per mile. This guarantee persuaded the Treasury to finance the line in 1907.

For its construction, Sir Percy Girouard obtained the services of three R.E. officers, Captain Mance, Lt. Maxwell and Lt. Hammond, and thirty N.C.O's and men of the 8th and 10th Railway Coys., R.E.

The work was in charge of Capt. Mance, who was afterwards head of the Railway Directorate at the War Office during the Great War.

In order to push on the work without delay railway stores and plant were shipped to Nigeria before the usual facilities for landing them at Baro had been provided. Ingenious improvisations had to be made for landing locomotives and a large tonnage of material.

Lt. Hammond was in charge of the Locomotive and Workshops Department, with Lance-Corp. Hatfield as running shed foreman, and Lance-Corp. Goddard as works' foreman.

Lt. Hammond is now Brig. General, and has for many years been specially employed by the Colonial Office to inspect and report upon Colonial railways all over Africa. He is at this moment returning from performing this duty on the railways in Iraq, and in Nyasaland. He served on a committee appointed to advise the Colonial Office as to the allocation of a loan of ten millions to various East African Colonies for railway development.

Captain Mance put Lt. Maxwell in charge of the platelaying. He is now Col. G. A. P. Maxwell, General Manager of the Railways which we took over from the Germans in Tanganyika Territory.

A record in platelaying was established by the laying of 6⅓ miles of main line and 400 yards of siding in one day, a truly wonderful performance.

Of course it must be understood that nothing like this can be done day after day, in fact their best record for 90 consecutive days was 120 miles, which gives the very satisfactory daily average over a period of three months of 1⅓ miles.

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Conspicuous in this platelaying success was Coy. Sergt.-Major Curtis. During the great War he rose to the rank of Captain. The latest news I have of him is that, in 1924, he was back in Nigeria as an Assistant Engineer on the construction of the Nigerian Eastern Railway.

The railway was completed in three years, which was much below previous estimates of time. Sir Percy Girouard had aroused the enthusiasm of every official in the Colony to co-operate in solving numerous ancillary problems, such as the supply and feeding of native labour, and the steady supply of shipping on the Niger up to Baro.

Lagos-Yebba Telegraph Line.

The first telegraph line in Nigeria from Lagos to Yebba was built by Lt. E. V. Turner, R.E., who took out 20 N.C.O's and men from Aldershot, and completed the job within a year. Later we come across Turner in charge of the Telegraph Administration of the Sudan, and he is now Colonel on the General Staff for Signals at the War Office.

The Congo.

Lieutenant W. G. Stairs, R.E.

Below the Niger we come to the Congo, which immediately recalls the name of Lt. Stairs, R.E.

He was one of the dozen white men selected by Sir H. Stanley to help him in his expedition for the rescue of Emin Pasha.

Emin Pasha had been appointed Governor of the Equatorial Province of the Sudan by Gordon, when he was Governor-General of the Sudan.

When the Mahdi rose in rebellion and captured Khartoum with his Dervishes, Emin Pasha was completely cut off, and no news came through from him. It was decided to organise an expedition to bring him out.

Sir H. Stanley was famous for his African explorations and for finding Dr. Livingstone. He was, therefore, asked to undertake the task.

Having selected a small number of men, including Stairs, to assist him, he journeyed up the Congo, which was completely unknown country, and reached Equatorial Africa, where he found Emin Pasha, and brought him out through East Africa. The expedition had thus made the first journey from west to east through the heart of Africa. They took Emin Pasha to Cairo, where his reception was so hospitable that he fell off a verandah and broke his neck.

Stairs had become so enamoured of African exploration that he resigned his commission in the British Army and accepted service under the King of the Belgians, with the mission to acquire, and develop, the Congo territory as a Belgian colony. It was mainly

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due to him that Belgium possesses that valuable country, in the acquisition of which he lost his life.

South Africa.

Now moving on to South Africa, we come to a large country where numerous R.E. have worked.

The earliest trace of R.E. work that I have come across is a road in Eastern Cape Colony.

The early settlers at the Cape waged intermittent frontier warfare with the Kaffirs in the neighbourhood of King Williams Town and Grahams Town. Through a "Pass" in the hills on that frontier there runs a well-graded road, which is in use to-day just as it was constructed. In the rock-cutting at the summit of the Pass there is an inscription to say that it was made by a Company of Royal Engineers in, I think, about the year 1840. I am sorry to say I have forgotten the number of the Company, but I believe it was the 42nd.

Bechuanaland.

The Bechuanaland Protectorate was secured for the British Empire by an R.E., Colonel (afterwards General) Sir Charles Warren.

He was despatched as High Commissioner and Commander of a Force to forestall the Transvaal Boers who, under the orders of their President, Kruger, were preparing to annex Bechuanaland.

By a mixture of diplomacy and a judicious display of force, Sir Charles Warren manœuvred the Boers out of the country, and established a British Protectorate.

He had with him on this Expedition Lt. Haynes, R.E., who had previously worked with Sir Charles Warren on a dangerous secret service mission in Arabia.

Captain Haynes in Mashonaland.

We next hear of Haynes in Mashonaland. In May, 1896, Captain A. E. Haynes embarked with his 43rd Fortress Coy, R.E., on the s.s. *Garth Castle*, to proceed to Mauritius for a tour of duty.

He probably thought he was about to spend some rather monotonous years in Mauritius, but the ship reached Durban just at the moment when a very serious native rising occurred in Mashonaland. A Relief Column to assist the settlers was being assembled at Beira under the orders of Colonel Alderson.

Haynes promptly took the initiative and telegraphed to G.O.C., Cape Town, suggesting that he should arm and equip the detachment of troops on board to join Col. Alderson. His detachment consisted of 4 R.A., 38 R.E., and 49 York and Lancaster Regiment.

The G.O.C. approved Capt. Haynes' suggestion. His small force landed at Beira and took part in Colonel Alderson's operations, which saved Mashonaland. Unfortunately, Haynes was killed in action storming Makoni's stronghold.

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The Corps has a permanent memorial to Captain Haynes in a medal which is competed for annually at Chatham.

The South African War.

We now come to the South African War. In the last 18 months of that war the Army in South Africa was commanded by Lord Kitchener. When he returned to England on the conclusion of the campaign, we dined him at the Chatham Mess, and I remember that in his speech he told us that, while he was carrying on the war in South Africa, the Prince of Wales (now H.M. King George V) landed at Durban, on his return voyage from Australia. Lord Kitchener went to Durban to meet him, and was greeted by the Prince of Wales with the question, " How is it that on landing at Durban I find that the Governor of Natal, Sir Henry Macallum, is an R.E., the Prime Minister of Natal, Sir Albert Hime, is an R.E., and the C.-in-C. of the Army of South Africa is an R.E."

Lord Kitchener said that he replied to the Prince of Wales by referring him to the Corps motto, "*Ubique quo Fas et Gloria ducunt.*"

General Sir Bindon Blood, whom we often see at Chatham and Aldershot looking hale and hearty, commanded a group of columns in the South African War.

Lt. Colonel Hunter-Weston (now Lt. General Sir Aylmer Hunter-Weston) was a Column Commander; also Lt. Colonel Gorringe (now Lt. General Sir George Gorringe).

The Blockhouse Lines.

The Engineer-in-Chief in the South African War was Major General Sir Elliott Wood. It devolved upon him to make practicable Lord Kitchener's blockhouse scheme, which eventually rounded up the Boer Columns.

The whole vast area of the theatre of war was divided up like a chess board, with lines of blockhouses connected by barbed wire fence. Several thousand blockhouses, and thousands of miles of barbed wire fencing, had to be rapidly erected by the organisation created by Sir Elliott Wood.

It was first necessary to settle the best type of blockhouse, suitable for rapid mass production, easy transport, and quick erection.

The Boers at this stage had lost all their artillery, so it was only necessary for the blockhouse to be bullet-proof.

Major S. R. Rice, commanding the 23rd Field Coy., R.E., who was afterwards Engineer-in-Chief in France in the Great War, evolved for this purpose the corrugated iron and shingle blockhouse, which is now in our text-book, and started with his Company the first factory for its mass production.

Armoured Trains.

On the railways these blockhouse lines were reinforced by several armoured trains, mounting machine guns, field guns, and search-

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lights, which were constructed, trained and commanded by Major H. C. Nanton, R.E. These armoured trains used to concentrate rapidly on the section of railway line which the Boers were reported to be about to cross, and made a formidable reinforcement to the block-house defences.

RAILWAY AND TELEGRAPH WORK IN SOUTH AFRICAN WAR.

On the Railway and Telegraph systems of South Africa the R.E. had an enormous amount of work to do in the South African War, under the guidance of Lt. Col. Girouard as Director of Railways, and of Col. Hippisley as Director of Telegraphs.

RAILWAY WORK.

Lt. Colonel Girouard had to organise a transportation Staff to work in harmony with the Cape Government and Natal Government Railways, and also had to create an organisation to take over, repair, and work, the enemy's railways, as our Army advanced into the Free State, with its 400 miles of railway, and into the Transvaal with a further 900 miles, total 1,300 miles of enemy's railways.

The enemy carried out the most wholesale destruction of the railways as he retired. Of the bridges, he demolished 53 spans of 100 ft. or over, 27 spans between 75 ft. and 100 ft., and 210 spans less than 75 ft. Some of these bridges spanned deep ravines.

At most stations the water supply was destroyed, and frequently the permanent way was blown up for several miles.

Nevertheless, railway communication was opened with Johannesburg eleven days after Lord Roberts arrived there, and with Pretoria sixteen days after the Army's arrival, and with Mafeking thirteen days after its relief.

The conquered railways were repaired, staffed, and worked, partly by R.E. officers, N.C.O.'s and men; the R.E. Coys. being the 8th and 10th Rly. Coys., R.E., the 6th, 20th, 31st, and 42nd, Fortress Coys., R.E.

These were an invaluable nucleus, but their numbers were small, and the great bulk of the railway men came from various sources.

Firstly, there were the British railway employees of the Orange Free State, who left their employment on the declaration of war, and returned with us to their old posts on the railways.

In the Transvaal, however, the railway employees were all Dutch from Holland, and these declined in a body to work for us, and were deported, thus effecting a more complete and simultaneous railway strike than we have ever had in England.

Some railway men were obtained on loan from the Cape Government Railways, some were recruited in England, but a very large number of men were obtained by calling for the services of railway men who were to be found in the ranks of the Forces, particularly among the Colonial Troops.

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Several men, who had never worked on a railway, but were tired of trekking about Africa, reported themselves as expert railway men, prepared to take on any job, even driving a locomotive, or working a signal-box. These had to be weeded out and returned to their regiments, not before, however, one of these amateur engine-drivers had upset a train containing a whole Battery of Artillery into a river bed.

With this heterogeneous, but zealous, body of several thousand men, more or less expert, the working of 1,300 miles of damaged railway had to be taken over and organised.

Conspicuous in this improvised railway organisation was the Railway Pioneer Regiment, officered and recruited from the highly-skilled mining engineers and artisans of Johannesburg. The raising of this unit was initiated by a very eminent mining engineer, Mr. Seymour, who took the post of second in command as a Major. He was, unfortunately, killed in action.

To help the formation of this unit a few R.E. officers and N.C.O.'s were posted to it, three of whom have since attained considerable distinction. Lieut.-Col. Capper commanded the Railway Pioneer Regiment. He is now Lt.-General Sir John Capper. Captain E. D. Swinton was a company commander. He is now Major-General Sir Ernest Swinton, Professor of Military History at Oxford. Lt. S. H. Wilson was a company officer. He is now Brig.-General Sir Samuel Wilson, Permanent Under Secretary of State for the Colonies.

The Railway Pioneer Regiment did some magnificent work in the reconstruction of demolished railway bridges.

Among the officers who assisted Lt.-Col. Girouard to carry out this railway work were Capt. Waghorn, now Brig.-General Sir W. Danvers Waghorn, who finished his career as President of the Indian Railway Board. Major Twiss, who was afterwards Director of of Railways in France during the Great War. Major Murray, now Sir Valentine Murray. Lt. Micklem, who carried out the bulk of the rapid repair work, was wounded in the foot when De Wet raided the construction train. As he had previously been wounded in the foot at the Battle of Khartoum, General Maxwell wired to him that his feet were too big for military purposes. Lt. Stevenson was Locomotive Superintendent. He is now Major-General Stevenson, recently Chief Engineer at Aldershot. He was assisted by Lt. Newcombe and by Lt. Oakes, who is now Asst.-Director of Transportation at the War Office. Major W. S. Nathan, brother of Sir Matthew Nathan, was Staff Officer to Lt.-Col. Girouard. He is now head of the Chinese Mining Engineering Company. Lt. Leggett, now Sir Humphrey Leggett, Captains F. G. Fuller and Sewell, Lts. North, Cunnington and C. G. Fuller, and Captain H. G. de Lotbinère were also amongst the officers employed on this work.

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Lt. Manifold, now Major-General Sir Graham Bowman-Manifold, was responsible for repairing the destroyed railway telegraphs and for working them.

Telegraph Work in South African War.

While Lt.-Col. Girouard was doing this work on the railways, Lt.-Col. R. L. Hippisley was doing analogous work on the telegraph systems of South Africa. He put Capt. Fowler (now Lt.-General Sir John Fowler) in charge in the Free State. He was afterwards Director-General of Signals in France in the Great War.

Captain E. G. Godfrey-Faussett was responsible for the telegraph system of the Transvaal.

Crown Colony Government of South Africa.

Work of R.E.

When peace was concluded in South Africa, Crown Colony Government was established in the Transvaal and Orange Free State, and these countries had to be reconstructed and administered.

In this work the Royal Engineers played a considerable part.

Sir Percy Girouard was appointed Commissioner for Railways, and kept some R.E. Officers working with him. A programme of 1,000 miles of new railway construction was put in hand.

Lt.-Col. Fowke (now Lt.-General Sir G. Fowke), who was afterwards Adjutant-General in France during the Great War, created and administered the Public Works Department of the Transvaal. In this he was assisted by Capt. R. N. Harvey, now Major-General Harvey, who is Engineer-in-Chief in India.

Colonel H. M. Jackson created and administered a Survey Department for the Transvaal and Orange Free State.

Major Leggett worked on the repatriation of the Boers.

Col. W. Peacock was Chief Engineer in South Africa after the war, and constructed large cantonments for the considerable force that was garrisoning South Africa for some years after the war.

R.E. in South Africa To-day.

At the present day we find the Royal Engineers still prominently represented in South Africa by Sir John Chancellor, who is Governor and Commander-in-Chief in Southern Rhodesia, having previously been Governor of Mauritius and of Trinidad.

Col. C. F. Birney is General Manager of the Rhodesian Railway system, stretching up to Katanga, in the north, and to Mashonaland in the east.

Rorke's Drift.

We must not leave South Africa without referring to that very gallant feat of arms at Rorke's Drift, in Zululand, which is always associated with the name of Lt. J. R. M. Chard, R.E., and for which he was awarded the Victoria Cross.

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There had been a disaster at Isandhlwana; our force there had been wiped out by the Zulus, who then started to pour down upon Natal. Their route took them through Rorke's Drift, where Chard and Lt. Bromhead, of the South Wales Borderers, had constructed a strong defensive post. The Zulus decided to attack the post, and expected to have no difficulty in mopping it up before they went on to Natal. A terrific fight lasted for over twenty-four hours, with desperate hand to hand fighting. Thousands of Zulus were slain and they were beaten off. Discouraged by their losses, they gave up their proposed incursion into Natal. It was generally recognised that Lt. Chard's skilful and gallant defence at Rorke's Drift saved the Colony of Natal from a frightful disaster.

Captain B. L. Sclater, R.E., in Nyasaland and East Africa.

In Nyasaland, or British Central Africa, we find the work of an R.E. who played a great part in opening up Africa.

Captain Sclater, R.E., made the first road from the coast into and through Nyasaland.

I have not found any particulars of his work in Nyasaland, except that it was road work, but, when he had finished there, he moved on to East Africa to make an unmetalled road for ox transport from Mombasa to Lake Victoria Nyanza.

On that work he was assisted by Lt. G. E. Smith, R.E., better known as "Uganda Smith." He is now Brig.-General Smith, retired, and he sent me a most interesting pamphlet which he published, describing the work which Sclater and he did in the construction of this road.

The first 180 miles of road from the Coast had been made by the Imperial British East Africa Coy., and Sclater's job was to carry it 400 miles further through only partially explored country to Victoria Nyanza.

Five R.E. N.C.O.'s assisted them: Lce.-Corp. Smith, Corp. Ellis, 2nd Corp. Clarke, Lce-Corp. Simmonds, and Lce.-Corp. Brodie.

Exploring and reconnoitring for the road through all kinds of country, plains, hills, ravines, forest, bush, etc., laying out the road, and constructing bridges, were the engineering problems that confronted them, but problems of a different nature also had to be dealt with.

In 1895, British East Africa had few white people in it. Negotiations with native tribes for the supply of labour, the organising of caravans of transport to obtain food, and to supply it to the working parties; the arrangements for payment. These questions all required considerable organising and administrative talents. Captain Sclater possessed unusual powers of influencing natives and gaining their friendship and co-operation.

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Several times they had to interrupt their work to march to the assistance of some of the small garrisons that were dotted about the country to keep order.

In those days there was no coinage current in East Africa. Payment was arranged by barter, and currency varied in every district. It might be brass wire, iron wire, American and Bombay sheeting, beads, old uniforms, cartridge cases, knives, looking-glasses, etc., etc.

Lt. Smith writes in his pamphlet :

> " I found it necessary to enquire into the price of food and animals which had been bought in my absence. It was a difficult job. My headman, following their usual custom, used to allude to every item as being worth so many sheep, and each sheep as being worth so many rings of brass wire, but I soon found that, though a sheep might be worth ' x ' rings of brass wire, and an ox worth ' y ' sheep, the ox was not worth ' xy ' rings of brass wire. I had to invent a fabulous animal, which I called an ' exchange sheep,' to get over this difficulty, the ' exchange sheep ' being worth about half what the real animal cost."

It is quite evident that Lt. Smith was not followed into the heart of Africa by a Local Auditor.

Their adventures with wild animals, and the excellent big game shooting, made a pleasant variant to the normal work. There used to be several trophies of Uganda Smith's rifle in the R.E. mess.

The unmetalled road, 400 miles in length, was completed in a little over 18 months for an expenditure of £17,000, which is £42 10s. 0d. per mile, a fabulously cheap performance. I think Smith must have done some skilful work with the currency, and inflated his "exchange sheep " a bit.

The road being finished, the Government then asked Sclater to create, and organise, a Government ox-transport service along the road from the coast to the lake.

Sclater started to do this, but, unfortunately, his energetic work over a period of years in tropical Africa had undermined his health, and he died at Mombasa.

THE UGANDA RAILWAY.

Roads alone will not develop a new country. Railways also are necessary.

In 1891-92, Captain (now Major General Sir) J. R. L. Macdonald, R.E., surveyed for a railway from Mombasa to Uganda.

The party consisted of Macdonald, Captain J. W. Pringle (who is now Sir John Pringle, Chief Inspector of Railways to the Ministry of Transport), Lt. P. G. Twining (afterwards Director of Fortifications and Works), and Lt. H. H. Austin (now Brig. General), all of whom had gained their experience on railway surveys in India, on the Kabul River, and in the Zhob Valley.

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They divided into two survey parties, which in nine months marched 4,280 miles, surveyed 2,724 miles, and located a railway route 657 miles in length.

When the railway was subsequently built Macdonald's location was adhered to, except in the last section approaching lake Victoria Nyanza, where an alternative route was followed, but now, after a lapse of thirty years, they find that Macdonald was right, and a line is being built on his original location.

Expeditions in East Africa.

In 1897, Macdonald was given command of an important expedition, which set out from Mombasa to forestall Marchand at Fashoda.

The French had started Marchand from West Africa to get a footing on the Upper Nile, hoping thereby to neutralise the effect of Lord Kitchener's approaching re-conquest of the Sudan. Macdonald's Expedition was a counter to Marchand's.

When, however, he was passing Uganda, he was recalled to that Colony to put down a very serious mutiny of native troops. This duty, perforce, occupied so much time that his expedition to Fashoda had to be abandoned as too late.

Macdonald, Austin, Gwynn, Maud, L. C. Jackson, led numerous survey expeditions, exploring and mapping the country between East Africa and the Sudan and Abyssinia, delimiting the frontiers between the two last named.

One of Austin's expeditions suffered terrible hardships, and he had great difficulty in extricating a small remnant of his followers from the attacks of hostile natives.

Other R.E. in East Africa.

One of the most successful Governors of British East Africa was Sir Percy Girouard, who moved to East Africa after governing Nigeria.

At the present day the Corps is represented in East Africa by Brig.-Gen. G. D. Rhodes, who is Chief Engineer of the Kenya Uganda Railways, engaged upon a programme of new railway construction costing four to five millions.

I have already mentioned that Col. G. A. P. Maxwell is General Manager of Railways in Tanganyika.

Abyssinia.

Abyssinia lies next to East Africa. The only European Force that ever fought its way into the heart of Abyssinia was commanded by an R.E., Field Marshal Lord Napier of Magdala, who captured Magdala in 1868.

R.E. Field-Marshals.

Talking of Field-Marshals reminds me that in my service I have seen four R.E.'s who have attained that rank—Lord Napier, Sir

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Lintorn Simmons, Lord Kitchener and Lord Nicholson, so that I think we may say that the Corps has provided its quota of great leaders to the army.

SOMALILAND.

In Somaliland, Col. H. G. C. Swayne, R.E., was the pioneer of big game shooting, and the recognised authority on sport in that country.

There have been several expeditions in Somaliland in which the Corps has played its part, but we must pass on to the Sudan and Egypt.

THE SUDAN AND EGYPT.

GORDON AND KITCHENER.

In these countries, the first R.E. names that will occur to everyone are Gordon and Kitchener.

Their deeds are well known to you all. How Gordon was for many years Governor-General of the Sudan on behalf of the Khedive of Egypt. How, after he had left the Sudan, a revolt against Egyptian rule broke out under the Mahdi. The British Government, who had by then assumed responsibility for Egypt, did not consider that Egypt had at that time the resources in men and money to reconquer the Sudan. They therefore sent out Gordon to evacuate the Egyptian garrisons. How he was besieged at Khartoum, and killed there when the Mahdi captured the place after a prolonged siege, which was maintained entirely by Gordon's personality. Lord Wolseley's expedition had been despatched too late in 1884 to rescue the beleagured garrison.

It was at this time that Major Kitchener first came into public notice. Before Lord Wolseley's expedition had been sanctioned by the Home Government, and while it was still very uncertain whether Gladstone would be persuaded to despatch such an expedition, Major Kitchener went as an Intelligence Officer to Dongola, hundreds of miles beyond any support, to keep an eye on the Emir of that province, and hold him to the Egyptian cause. If the Home Government had not sanctioned Lord Wolseley's expedition there is no doubt that Kitchener would never have returned from Dongola. However, Lord Wolseley, as we all know, was allowed to proceed with the attempt to relieve Gordon at Khartoum. Later on, Kitchener commanded an Egyptian cavalry regiment, an Egyptian infantry brigade, was Governor of the Red Sea Littoral, reorganised the Egyptian Police, and was appointed Sirdar of the Egyptian Army.

SIR GERALD GRAHAM AT SUAKIM.

While Lord Wolseley's Expedition was making its way up the Nile, a Force was sent to Suakim to occupy the Dervishes in that area, and to prevent them moving to oppose Wolseley. The Suakim Force was commanded by an R.E., Lieut. General Sir Gerald

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Graham, V.C. At El Teb and Tamai he gave the Dervishes two of the hardest blows they ever received.

Other R.E.'s with Lord Wolseley in Egypt and the Sudan.

Many other Royal Engineers distinguished themselves in Egypt and the Sudan at this period. It is only possible to mention a few.

Col. C. M. Watson was on the Intelligence Staff when Lord Wolseley conquered Egypt in 1882, and played a great part in the capture of Cairo by Sir Drury Lowe's cavalry.

Colonel (now General Sir Richard) Harrison, was A.Q.M.G. of L. of C. Staff in the 1882 Egyptian Campaign.

Colonel Sir Charles Wilson was Lord Wolseley's Chief Intelligence Officer when he was trying to relieve Gordon at Khartoum, and took over command of Sir Herbert Stewart's Column when that officer died at Metemmeh from wounds. Sir Charles Wilson proceeded in a steamer right up to Khartoum, and brought back the news of its capture.

General Sir Herbert Chermside was Governor of the Red Sea Littoral.

The Reconquest of the Sudan.

In March, 1896, Sir Herbert Kitchener, as Sirdar of the Egyptian Army, received instructions from the Government to start upon his famous reconquest of the Sudan, which culminated 2½ years later in the battle of Khartoum.

Many Royal Engineers took part in these operations. Captain Gorringe (now Lt. General) was A.Q.M.G. of the Egyptian Army, and responsible for the organisation of supplies and transport on which the success of the Expedition so much depended.

Major Kincaid was on the staff of a division. Major Lawson (now Lt. Gen. Sir H. Lawson) commanded Arab levies.

Railway Work in Sudan Campaign, 1896-99.

A great feature of the Campaign was the railway work carried out by Lt. Girouard with R.E. officers, assisted by N.C.O's and men of the 8th and 10th Railway Companies, R.E.

Five-hundred-and-eighty-five miles of railway were built in 2¼ years—200 miles from Wady Halfa to Kerma in the Dongola Province, and then 385 miles from Wady Halfa via Berber to Abuhamed.

You will notice how often in this lecture I have had occasion to refer to the work of N.C.O.'s and men of the 8th and 10th Railway Coys., R.E. It really is remarkable how the men of these two small companies have left their mark all over Africa in the construction of important railways, which are serving that continent.

From Wady Halfa to Abuhamed the railway crossed 235 miles of waterless desert. A former Khedive of Egypt had tried to find

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water by sinking wells in many parts of this desert, but had always failed. It was not anticipated that we should have any better success, but two R.E. subalterns (one of whom is now Major-General Stevenson), after reconnaissance, found a place about ninety miles from Wady Halfa where they thought it worth while to sink a well, and, to everyone's surprise and satisfaction, a splendid unfailing water supply was found which has filled up every locomotive from that day to this.

Other attempts to find water were made elsewhere along this desert railway route to Abuhamed, but so far without success. The finding of this water facilitated the building of the railway across 235 miles of desert, although the problem of watering construction parties and locomotives still remained a formidable one.

The Corps lost two very promising subalterns in the construction of these desert railways—Lieuts. R. Polwhele and E. H. S. Cator.

Telegraph Work in Sudan Campaign.

Lt. Manifold (now Major-General Sir G. Bowman-Manifold) was responsible for the telegraph work throughout the campaign.

Administration and Development of the Sudan.

I cannot attempt to tell the story of the reconquest of the Sudan, or of all the fighting in Egypt and the Sudan from the time Lord Wolseley landed there up to the present day.

The British Government became responsible for the administration and development of these countries, and the R.E. took up a big share of the work.

Lord Kitchener was, of course, the first Governor-General of the reconquered Sudan.

Col. Gorringe was Governor of the Blue Nile Province. I have already referred to R.E. work on survey of the Sudan and Egypt.

Captain J. S. Liddell was head of the Sudan Telegraph Dept. When he took over the telegraphs of Egypt he handed over the Sudan telegraphs to Lt. E. V. Turner, who is now Colonel on the General Staff for Signals at the War Office. Turner was succeeded by J. P. Moir, who is now Chief Engineer Anti-Aircraft Defences of England.

Captain M. R. Kennedy became Director of Public Works in the Sudan. This officer first came into notice by designing a scaffold which would hang six brigands simultaneously in Crete, at the time when an International Force was operating there under the command of Major General Sir Herbert Chermside.

The designing of such a scaffold seems hardly sufficient qualification for appointment as Director of Public Works in the Sudan, but he selection was justified, as Kennedy carried out some very important works and buildings in that country.

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Port Sudan.

Probably his most important work was the construction of a fine new harbour at Port Sudan on the Red Sea. As its name implies, it is *the* port of the Sudan. His Resident Engineer for this great work was Lt. Kelly, R.E., who was unfortunately killed in France in the Great War. Some idea of the size and nature of this harbour work can be given by the following few particulars :

There are five berths, each 410 feet long, which vessels run alongside.

One berth is equipped with four large electric coal transporters, delivering either direct into truck, or to a coal-distributing bridge in rear.

For general cargo, four 3-ton, and 7 ton, electric jib cranes are fitted, which can be used for cargo on any of the five berths.

A floating crane deals with loads up to 60 tons.

On the quays are four Customs' sheds.

In 1924, 699 vessels entered the port, whose total tonnage was 2½ millions, and they landed and shipped 481,000 tons of cargo.

The largest vessel that has entered the harbour had a tonnage of 27,000.

The Sudan and Egyptian Railways.

Major Girouard handed over the Sudan railways to Major Macaulay (now Sir George Macaulay) when he proceeded to take up the very important post of President of the Egyptian Railway and Harbour Board. When he left that appointment to proceed to the other parts of Africa in which we have traced his activities, Major Macaulay succeeded him in Egypt, after handing over the Sudan Railways to Captain E. C. Midwinter, R.E., under whom the system was greatly extended and improved. In this he was assisted by several R.E. Officers, among whom I would mention Newcombe, Sowerby, a very able R.E. Officer who died in Palestine during the Great War, and Russell, who recently handed over command of the Training Battalion at Chatham, in order to take up the appointment of Military Attaché in Chile.

Midwinter is now Controller of Sudan Railways in the London Office of the Sudan Government.

Blakeney, now Brigadier-General, and Clifford Hall, now Colonel, moved from the Sudan to work in the management and traffic departments respectively of the Egyptian Railways. Blakeney in due course became General Manager, and Hall, Traffic Manager. The latter is now a Director of the Anglo Egyptian Bank.

Military Works of Egyptian Army.

The military works of the Egyptian Army were in the hands of the Royal Engineers, first under Col. L. B. Friend, who was afterwards

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Director of Fortifications and Works at the War Office. Major P. G. Grant, now G.O.C., Chatham, and Inspector of R.E., was also head of the Military Works of the Egyptian Army.

CONCLUSION.

We have now travelled over most of Africa.

I have omitted many names of R.E., and much useful work done by them in Africa. Notably I have omitted their good work in the Great War in Africa, because it is impossible to give an exhaustive account within the limits of this lecture.

To recapitulate, I have shown you how Royal Engineers have played a prominent part in every campaign, and in every expedition in Africa.

How they have played a great part in opening up and developing that great continent by surveying it, by constructing harbours, railways, roads, telegraphs, buildings, water supplies, and numerous other works, and last, but not least, by administering and governing some of its territories.

The Great War showed what excellent training for Engineers in war this work in Africa had given to the men who did it.

But the work they have done has only served to open up this vast continent, and to start its development. The African Continent awaits the Royal Engineer of the new generation to carry that development several stages further.

That brings me back to the point with which I started this lecture, which was to show you the great *variety* of the opportunities, and of the work, which come to the Royal Engineers, and I have been dealing only with Africa, which is only a portion of the British Empire.

By all means get into the Staff College if you can, but you can't all get into the Staff College, even under the latest Army Orders. Only 17 out of the 111 officers I have named in this lecture passed through the Staff College.

But, whether you go to the Staff College, or whether you don't, we may reasonably expect that the work which lies before you in the great British Empire will offer you as great a variety, and as many opportunities, as your predecessors enjoyed, and that you will thus be able to train yourselves by interesting and constructive work in the British Empire for your duties as Royal Engineers in War.

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CO-OPERATION BETWEEN R.E. AND R.A.F. IN AND BEYOND INDIA.

By MAJOR A. V. GOMPERTZ, M.C., R.E.

SCOPE.

This article is offered as a corollary, not a disputant, to Brevet-Major Dewing's article in the June, 1926, issue. With the exception of the two premises given below, and of one point of detail, the former article may be applied equally to India. The scope of these notes is intended to cover the work which any R.E. officer must be prepared to take charge of in peace and war, in India, and in a war conducted from India, particularly beyond the North-West Frontier. Where detail is descended to, it is local detail only.

TWO PREMISES.

The first and most important of these is the diametric difference which obtains between the R.A.F. works and building services, at home and in India respectively. At home, as Major Dewing points out, this service is a civilian one, possibly enlistable on the outbreak of war. In India, all works for the R.A.F. beyond the province of their own technical sections for aeroplanes and motor transport, are executed through the single agency of the R.E., in the Military Engineering Service. This covers anything, literally, from patch repairs to a landing ground, up to the construction of an entire new R.A.F. Cantonment such as we have at Drigh Road.

Whether or not the home R.A.F. works organization is enlisted on the outbreak of war, it is, and foreseeably will long remain, out of the question to consider a similar system for India. There exists in peace time no civil R.A.F. works staff ; 1914-8 taught us fully the dangers of avoidable improvisation in all quarters ; and there is, moreover, in India no such civil reserve of competent engineers as is to be found in European countries. In a large or a long war based upon India the R.E. cadre would certainly be expanded by civil engineers with temporary commissions ; but it may be taken as virtually certain that the R.A.F. works service will remain in war, as it is in peace, the business of the parent Corps in the first place.

In the writer's opinion the arrangement is a very fortunate one, at any rate for the Corps. One of its direct effects is that, in peace time, an appreciable number of R.E. officers of all ranks are in a position to obtain a close insight into the working and requirements of the Royal Air Force, to a degree which would be very difficult to obtain in Great Britain ; and they are thus able to store up personal experience which should prove of great value to both arms in war.

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The second premise, in respect of conditions in and beyond India, is the greater quantity of R.A.F. work which must fall to the R.E. compared with that which they would be likely to encounter in an European war. The writer begs to support most strongly Major Dewing's statement that " It is all very well to call the preparation of aerodromes the ' duty ' of the R.A.F.; it certainly sounds like being the work of the Army." In India there is practically no other side to the question at all. In India, as at home, the personnel of the Royal Air Force has at its disposal very few men-hours indeed in proportion to those required for purely flying duties and those duties directly ancillary to them. In war this situation is likely to become much more marked still : neither in peace nor war can the taxpayer afford to maintain trained British airmen to do work which can be performed effectively and far more cheaply by local labour. Even landing grounds, which are very minor things when compared to aerodromes, need annually in India a good deal more work upon them than could ever be found by the R.A.F. personnel without disproportionate detriment to the flying service, and some of them in constant use are located hundreds of miles from the nearest R.A.F. unit. Standing regulations for landing grounds do, indeed, lay down that the R.A.F. shall only call upon the R.E. for such work as they are unable to perform themselves ; but in practice, climate, wind, weather and soil, to say nothing of finance, ensure that the bulk of the work falls on the Corps.

The Sapper east of Suez must thus be prepared, whether he is with a Divisional unit or on the Works Directorate, to do any or all classes of work for the R.A.F.

Bearing this in mind, it is fortunate that a large proportion of the Works and the Field cadre of the Corps in India is located broadly where the entire local complement of the R.A.F. works, i.e., on and north-west of a line joining Karachi and Delhi. In consequence, the prospects open to the R.E. officer of getting experience of R.A.F. works at some time or other during his Indian service are quite good.

It may be of use to look briefly into the main classes of work which would probably fall to the R.E. on behalf of the Air arm in a campaign within the theatres visualized, confining the list to items in which the limits of the Indian establishment of the R.A.F. would render it necessary for practically the whole of the work to be done by the Corps, with only a close and continual liaison with the R.A.F. to see that their requirements were accurately met.

Taking existing circumstances as they are, in the shape of squadrons, stations and the like : probably the first need in the tactical series would be for more landing grounds, both advanced ones for co-operation with the headquarters of Military formations, and emergency grounds for the safe landing of damaged machines and

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the execution of light repairs. As work upon landing grounds in India has special characteristics, which are in detail rather the province of the Sapper than of the Airman, a separate note on these is inserted later.

With the landing grounds, there comes at once the question of approaches to them from the existing ground communications, by road, or rail, or both, according to availability. A landing ground with no good communication to it by ground is less good than the proverbial sick headache. The road approach, moreover, should not only be good enough to stand ordinary medium loads, such as might be necessary in ordinary circumstances, but it should stand up at need to the heaviest R.A.F. vehicles, if time, labour and material permit. R.A.F. engines do not grow on trees, and the accident of a machine, with a write-off undercarriage and an undamaged engine, could make the easy access of a crane-lorry a very valuable asset when the engine supply base is hundreds of miles away.

Again, at the outset of operations, local bomb-proof, or, at the least, splinter-proof, protection for considerable stores of aerial bombs and fireworks could easily become a requirement of first importance at places far in advance of the usual arsenals and bomb-stores. So long as they are far enough back to be tactically safe—and in this both ground and air tactics are determining factors—the further forward that fighters, co-operation machines and bombers can leave the ground, the better.

So much for actual tactical considerations. Thereafter there come the questions of works which are second nature to the Sapper on the Indian establishment, to wit, hutting and/or housing, water supply, conservancy, workshops, electric light and power required in any excess over what the small R.A.F. portable plants can supply, assistance in the erection of hangars or their entire erection if they are big semi-permanent or permanent affairs, and so on. None of these items need any special note to the Sapper, save that of water supply, in view of the particular local conditions. On and beyond the frontier, water is an eternal question; and although it is so greatly important that both the strategical and tactical conduct of campaigns have to fall in closely with it, there are times when the Sapper will have to make special efforts to enable the field for strategy and tactics to be enlarged, just as was done upon the dry upland reaches north of the Somme in 1916, and in the arid country east of Port Said. As a general rule, the broad process will be the development of existing resources to the utmost, the use of a good deal of power plant of many designs is fairly certain to arise; but at times the active co-operation of civilian expert geologists and tube-well specialists may be a matter of high import. The Sapper likely to be employed upon works in the field on or beyond

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the frontier, for the Army and R.A.F. alike, can do no better than keep his water-supply knowledge thorough and up-to-date.

After this brief survey of possible works for the R.A.F., there remains to insert only a brief note on liaison. In practice, this can hardly be too close. There is never any question of the Sappers being under the R.A.F. for their technical work, although with big R.A.F. headquarters in the field there may be R.E. officers permanently attached, just as they are in certain positions in India in peace-time. It may be remarked that liaison does not lie only in office visits at stated hours; one of its strongest factors for efficiency is close personal acquaintance. In peace, in our own district, the R.A.F. were good enough to allow junior R.E. officers in direct charge of R.A.F. work to live in the R.A.F. Mess, if there was one in the station; the practice proved a great help, and should be equally good in war for all ranks employed on R.A.F. work alone.

LANDING GROUNDS.

Some special notes need to be made about landing grounds, since not only is this class of work one of the items whereat Sappers and Pilots come closest into co-operation, but out-station grounds are apt in practice to be almost entirely in R.E. charge, subject only to inspection by pilots.

Here it is necessary to differ in one detail from Major Dewing, who states that such grounds must be as broad as they are long and need only be 400 yards square for occasional use. The size varies with the main classes of machines likely to use them. The R.A.F. will always supply details; but in India a 400-yard square would not ordinarily be considered large enough for anything but a Bristol Fighter. For D.H.9-A's, the other normal type in India, it is best to allow not less than a 500-yard run. There are, of course, pilots who will put a machine down almost on the legendary "tennis court;" but the man to be legislated for is the ordinary pilot in trying weather, and it needs to be remembered that a machine can be put down without trouble on bits of ground where it may be very difficult to get it off again. The square shape is not vital, though of course desirable. The essential is to give a run of sufficient length in the direction of the prevailing wind or winds, of a breadth of 200 yards and upwards. In the writer's own district, landing grounds were of many shapes, from a 500 x 500 "L" shape of 300 yards width to the Aerodrome landing grounds of 1000 yards square. The R.A.F. fix what they will accept, and thereafter accurate ferrotype maps, continually up-to-date, should be distributed to those concerned, even in the case of temporary manœuvres landing grounds.

It has already been pointed out that in India a considerable charge of landing grounds often falls to the R.E.: the subject, therefore, needs careful study. Bad work at any time may cost a valuable

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machine, to say nothing of two very valuable lives, perhaps, as well. This is where the Sapper comes in. The Pilot knows what he wants; but it is not within his work to know exactly how to obtain and maintain it on all the different classes of ground in India. That is the Engineer's job, and it is thus of the first importance for the Sapper to know where a machine can land and where it cannot, and how to set matters right.

The easy grass of Britain is, in India, rather the exception than the rule; there are grounds of sand, of earth, of "put" (best defined as sun-baked mud), of powdery shale, and of any or all of these mixed with rock. Nor is there any golden rule for all their maintenance year in and year out. Quoting at random, the "put" ground at Sibi is a death-trap of deep heavy mud after a lot of rain: when dried out, its surface is a shiny billiard-board for the wheels, whilst it still breaks up comfortably well under the tail-skid so as to stop the machine quickly. From year's end to year's end it needs virtually no care, save for its barring from use during and after rain, and for the filling in of rat-burrows, which make wheel-traps as the rain washes them bigger. At Reti, one "hop" from Sibi for a 2-tanker Bristol, is a sand ground which can behave very well in ordinary weather, although a couple of hours of sandstorm can raise mounds costing at least an undercarriage. At Quetta is a big ground of sandy earth on a very slight slope; in 1924 a single hot-weather downpour tore nullas in it big enough to wreck the largest machine in the world.

It may be judged, then, that for the care or selection of landing grounds alone, quite apart from the much wider questions of reconnaissance and intelligence dealt with by Major Dewing, it is very desirable that the Sapper in charge of R.A.F. works should know the Pilot's point of view. This he can only get by being thoroughly at home in the back seat of a Service machine.

If he is to do his work with 100% efficiency, he must be fully at home in the air; he must know when a bad landing (seen or felt) is or is not the fault of the ground; he must know gliding angles by heart, and he must be able to pass fairly accurately any landing ground for any normal type of machine. The R.A.F. officer is naturally the final and only judge in these matters; but, as already indicated, he has neither time nor opportunity to find out exactly what in India is necessary to make a landing ground out of a particular wilderness. That is the Sapper's job; and the more he knows of the Pilot's outlook, the better will his work be for the side. To attain this, he must—"must" is the word—fly.

Suggested Training.

The following remarks constitute suggestions as to how the R.E. officer can set about proper liaison; they apply equally to a know-

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ledge of landing grounds as to the wider duties of reconnaissance, etc.

Opportunity in India is distinctly good for those officers who are in direct charge of R.A.F. work. There are, of course, the classes in Army Co-operation held by the A.C. Squadrons each training season, but the vacancies are few, and those falling to the Corps, of course, much fewer still. Nevertheless the Sapper on R.A.F. work can make a good deal of his own running without them.

Not only is he in continually close contact with the R.A.F. over his work, but the Army Co-operation Squadrons are frequently able to give lifts to Army passengers; and with other squadrons and Depots the necessary authorization to fly is easily forthcoming, so long as flying is restricted to duty trips in actual connection with work. The Royal Air Force is helpfulness itself, so long as there is a back seat vacant or a machine and Pilot free, and the job is one of genuine work.

It may, perhaps, be of use to describe the system laid down by the writer, as C.R.E. of two successive Districts, for the development of proper liaison. The object was, in the presence of the opportunities already mentioned, and in the natural absence of any cut-and-dried regulations governing a fluctuating case, to get the best out of those opportunities by systematic means, instead of leaving their exploitation to individual choice and chance. The affair being thus unofficial, no more than verbal and informal advice and approval was asked for from R.A.F. officers; but it can certainly be claimed that the system produced good results.

To begin with, every R.E. officer in actual charge of R.A.F. work had to fly. It was no difficulty to get them to do so: the difficulty lay in dealing patiently with their day and night requests for chances to fly more and more. Needless to say, such flying as was done was subject entirely to the orders and convenience of the R.A.F., who were at the same time more than kind in meeting requests. Next, officers were permitted an absolute maximum of six hours' air time in which to get "air sense" before being sent up on jobs of work. During that time, which spread naturally over some weeks or more, they had to pick up the more ordinary gambits and gadgets of the backseater's existence, such as:—

(i). Feeling absolutely at home in the air.
(ii.) Familiarity with air harness, and with working in it.
(iii). Helping to start up an engine—a vital necessity when halting at out-station landing grounds in India where there is often no one but a Pathan *chowkidar*.
(iv.) Filling up, use of the chocks, turning a plane round by hand, guiding a taxi-er by a wing tip, etc.
(v). Dropping message bags occasionally, and firing Very lights as wind indicators for the pilot.

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(vi). Reading and recording any of many dials for the Pilot if desired by him, and, of course, understanding them.

(vii). Simple cross-country navigation; this was second nature to the Sapper, of course.

(viii). No stunting, but keeping one's target in sight, as well as direction-sense in the more ordinary moves, such as steep sideslip descents and stalling turns.

(ix). Practising observation all the time.

They had, furthermore, to note take-offs and landings very carefully, and to watch other machines getting off and on, so as to study the behaviour of the ground.

It will be seen that the aim was not only to produce officers with air sense and with an insight into the pilot's point of view, but also to give the pilots reason to feel that they had behind them not merely so much deadweight, but a man who could do something towards earning his passage at halts and in ordinary slight trouble.

At the end of six air-hours, it was reckoned that R.E. officers should be quite fitted to take their places in back seats for all the ordinary work likely to come their way, to the natural exclusion of purely R.A.F. duties such as photography, wireless, and expert aerial gunnery. Thereafter they were not sent up save on definite duty, by the C.R.E's orders or the R.A.F's request, for specific tasks, such as :—

(*a*). Periodical inspection of outstation landing grounds This was the commonest trip. Apart from the advantage of inspection by landing, a comparatively short ferry trip would save the Sapper one or even more whole working days in view of the slow and restricted train services of India. A longish trip, with intermediate stops, would save anything from days to weeks.

(*b*). R.E. Reconnaissances, with or without amateur photography. (A V.P.Kodak will give surprising air photos.) A lot of useful work was done in this way, in tackling big storm-drainage and river-training problems, as a supplement to ground work.

(*c*). Special trips. These might include the selection (with or without landing) of new landing grounds, such as are temporarily required for manœuvres, the inspection by night of obstruction lights provided by the R.E., and occasionally quick ferry trips by the kindness of the R.A.F., for urgently arising and distant military duty; and odd special jobs generally.

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Several times they had to interrupt their work to march to the assistance of some of the small garrisons that were dotted about the country to keep order.

In those days there was no coinage current in East Africa. Payment was arranged by barter, and currency varied in every district. It might be brass wire, iron wire, American and Bombay sheeting, beads, old uniforms, cartridge cases, knives, looking-glasses, etc., etc.

Lt. Smith writes in his pamphlet :

> " I found it necessary to enquire into the price of food and animals which had been bought in my absence. It was a difficult job. My headman, following their usual custom, used to allude to every item as being worth so many sheep, and each sheep as being worth so many rings of brass wire, but I soon found that, though a sheep might be worth ' x ' rings of brass wire, and an ox worth ' y ' sheep, the ox was not worth ' xy ' rings of brass wire. I had to invent a fabulous animal, which I called an ' exchange sheep,' to get over this difficulty, the ' exchange sheep ' being worth about half what the real animal cost."

It is quite evident that Lt. Smith was not followed into the heart of Africa by a Local Auditor.

Their adventures with wild animals, and the excellent big game shooting, made a pleasant variant to the normal work. There used to be several trophies of Uganda Smith's rifle in the R.E. mess.

The unmetalled road, 400 miles in length, was completed in a little over 18 months for an expenditure of £17,000, which is £42 10s. 0d. per mile, a fabulously cheap performance. I think Smith must have done some skilful work with the currency, and inflated his "exchange sheep " a bit.

The road being finished, the Government then asked Sclater to create, and organise, a Government ox-transport service along the road from the coast to the lake.

Sclater started to do this, but, unfortunately, his energetic work over a period of years in tropical Africa had undermined his health, and he died at Mombasa.

THE UGANDA RAILWAY.

Roads alone will not develop a new country. Railways also are necessary.

In 1891-92, Captain (now Major General Sir) J. R. L. Macdonald, R.E., surveyed for a railway from Mombasa to Uganda.

The party consisted of Macdonald, Captain J. W. Pringle (who is now Sir John Pringle, Chief Inspector of Railways to the Ministry of Transport), Lt. P. G. Twining (afterwards Director of Fortifications and Works), and Lt. H. H. Austin (now Brig. General), all of whom had gained their experience on railway surveys in India, on the Kabul River, and in the Zhob Valley.

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They divided into two survey parties, which in nine months marched 4,280 miles, surveyed 2,724 miles, and located a railway route 657 miles in length.

When the railway was subsequently built Macdonald's location was adhered to, except in the last section approaching lake Victoria Nyanza, where an alternative route was followed, but now, after a lapse of thirty years, they find that Macdonald was right, and a line is being built on his original location.

Expeditions in East Africa.

In 1897, Macdonald was given command of an important expedition, which set out from Mombasa to forestall Marchand at Fashoda.

The French had started Marchand from West Africa to get a footing on the Upper Nile, hoping thereby to neutralise the effect of Lord Kitchener's approaching re-conquest of the Sudan. Macdonald's Expedition was a counter to Marchand's.

When, however, he was passing Uganda, he was recalled to that Colony to put down a very serious mutiny of native troops. This duty, perforce, occupied so much time that his expedition to Fashoda had to be abandoned as too late.

Macdonald, Austin, Gwynn, Maud, L. C. Jackson, led numerous survey expeditions, exploring and mapping the country between East Africa and the Sudan and Abyssinia, delimiting the frontiers between the two last named.

One of Austin's expeditions suffered terrible hardships, and he had great difficulty in extricating a small remnant of his followers from the attacks of hostile natives.

Other R.E. in East Africa.

One of the most successful Governors of British East Africa was Sir Percy Girouard, who moved to East Africa after governing Nigeria.

At the present day the Corps is represented in East Africa by Brig.-Gen. G. D. Rhodes, who is Chief Engineer of the Kenya Uganda Railways, engaged upon a programme of new railway construction costing four to five millions.

I have already mentioned that Col. G. A. P. Maxwell is General Manager of Railways in Tanganyika.

Abyssinia.

Abyssinia lies next to East Africa. The only European Force that ever fought its way into the heart of Abyssinia was commanded by an R.E., Field Marshal Lord Napier of Magdala, who captured Magdala in 1868.

R.E. Field-Marshals.

Talking of Field-Marshals reminds me that in my service I have seen four R.E.'s who have attained that rank—Lord Napier, Sir

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Lintorn Simmons, Lord Kitchener and Lord Nicholson, so that I think we may say that the Corps has provided its quota of great leaders to the army.

SOMALILAND.

In Somaliland, Col. H. G. C. Swayne, R.E., was the pioneer of big game shooting, and the recognised authority on sport in that country.

There have been several expeditions in Somaliland in which the Corps has played its part, but we must pass on to the Sudan and Egypt.

THE SUDAN AND EGYPT.

GORDON AND KITCHENER.

In these countries, the first R.E. names that will occur to everyone are Gordon and Kitchener.

Their deeds are well known to you all. How Gordon was for many years Governor-General of the Sudan on behalf of the Khedive of Egypt. How, after he had left the Sudan, a revolt against Egyptian rule broke out under the Mahdi. The British Government, who had by then assumed responsibility for Egypt, did not consider that Egypt had at that time the resources in men and money to reconquer the Sudan. They therefore sent out Gordon to evacuate the Egyptian garrisons. How he was besieged at Khartoum, and killed there when the Mahdi captured the place after a prolonged siege, which was maintained entirely by Gordon's personality. Lord Wolseley's expedition had been despatched too late in 1884 to rescue the beleagured garrison.

It was at this time that Major Kitchener first came into public notice. Before Lord Wolseley's expedition had been sanctioned by the Home Government, and while it was still very uncertain whether Gladstone would be persuaded to despatch such an expedition, Major Kitchener went as an Intelligence Officer to Dongola, hundreds of miles beyond any support, to keep an eye on the Emir of that province, and hold him to the Egyptian cause. If the Home Government had not sanctioned Lord Wolseley's expedition there is no doubt that Kitchener would never have returned from Dongola. However, Lord Wolseley, as we all know, was allowed to proceed with the attempt to relieve Gordon at Khartoum. Later on, Kitchener commanded an Egyptian cavalry regiment, an Egyptian infantry brigade, was Governor of the Red Sea Littoral, reorganised the Egyptian Police, and was appointed Sirdar of the Egyptian Army.

SIR GERALD GRAHAM AT SUAKIM.

While Lord Wolseley's Expedition was making its way up the Nile, a Force was sent to Suakim to occupy the Dervishes in that area, and to prevent them moving to oppose Wolseley. The Suakim Force was commanded by an R.E., Lieut. General Sir Gerald

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Graham, V.C. At El Teb and Tamai he gave the Dervishes two of the hardest blows they ever received.

Other R.E.'s with Lord Wolseley in Egypt and the Sudan.

Many other Royal Engineers distinguished themselves in Egypt and the Sudan at this period. It is only possible to mention a few.

Col. C. M. Watson was on the Intelligence Staff when Lord Wolseley conquered Egypt in 1882, and played a great part in the capture of Cairo by Sir Drury Lowe's cavalry.

Colonel (now General Sir Richard) Harrison, was A.Q.M.G. of L. of C. Staff in the 1882 Egyptian Campaign.

Colonel Sir Charles Wilson was Lord Wolseley's Chief Intelligence Officer when he was trying to relieve Gordon at Khartoum, and took over command of Sir Herbert Stewart's Column when that officer died at Metemmeh from wounds. Sir Charles Wilson proceeded in a steamer right up to Khartoum, and brought back the news of its capture.

General Sir Herbert Chermside was Governor of the Red Sea Littoral.

The Reconquest of the Sudan.

In March, 1896, Sir Herbert Kitchener, as Sirdar of the Egyptian Army, received instructions from the Government to start upon his famous reconquest of the Sudan, which culminated 2½ years later in the battle of Khartoum.

Many Royal Engineers took part in these operations. Captain Gorringe (now Lt. General) was A.Q.M.G. of the Egyptian Army, and responsible for the organisation of supplies and transport on which the success of the Expedition so much depended.

Major Kincaid was on the staff of a division. Major Lawson (now Lt. Gen. Sir H. Lawson) commanded Arab levies.

Railway Work in Sudan Campaign, 1896-99.

A great feature of the Campaign was the railway work carried out by Lt. Girouard with R.E. officers, assisted by N.C.O's and men of the 8th and 10th Railway Companies, R.E.

Five-hundred-and-eighty-five miles of railway were built in 2¼ years—200 miles from Wady Halfa to Kerma in the Dongola Province, and then 385 miles from Wady Halfa via Berber to Abuhamed.

You will notice how often in this lecture I have had occasion to refer to the work of N.C.O.'s and men of the 8th and 10th Railway Coys., R.E. It really is remarkable how the men of these two small companies have left their mark all over Africa in the construction of important railways, which are serving that continent.

From Wady Halfa to Abuhamed the railway crossed 235 miles of waterless desert. A former Khedive of Egypt had tried to find

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water by sinking wells in many parts of this desert, but had always failed. It was not anticipated that we should have any better success, but two R.E. subalterns (one of whom is now Major-General Stevenson), after reconnaissance, found a place about ninety miles from Wady Halfa where they thought it worth while to sink a well, and, to everyone's surprise and satisfaction, a splendid unfailing water supply was found which has filled up every locomotive from that day to this.

Other attempts to find water were made elsewhere along this desert railway route to Abuhamed, but so far without success. The finding of this water facilitated the building of the railway across 235 miles of desert, although the problem of watering construction parties and locomotives still remained a formidable one.

The Corps lost two very promising subalterns in the construction of these desert railways—Lieuts. R. Polwhele and E. H. S. Cator.

Telegraph Work in Sudan Campaign.

Lt. Manifold (now Major-General Sir G. Bowman-Manifold) was responsible for the telegraph work throughout the campaign.

Administration and Development of the Sudan.

I cannot attempt to tell the story of the reconquest of the Sudan, or of all the fighting in Egypt and the Sudan from the time Lord Wolseley landed there up to the present day.

The British Government became responsible for the administration and development of these countries, and the R.E. took up a big share of the work.

Lord Kitchener was, of course, the first Governor-General of the reconquered Sudan.

Col. Gorringe was Governor of the Blue Nile Province. I have already referred to R.E. work on survey of the Sudan and Egypt.

Captain J. S. Liddell was head of the Sudan Telegraph Dept. When he took over the telegraphs of Egypt he handed over the Sudan telegraphs to Lt. E. V. Turner, who is now Colonel on the General Staff for Signals at the War Office. Turner was succeeded by J. P. Moir, who is now Chief Engineer Anti-Aircraft Defences of England.

Captain M. R. Kennedy became Director of Public Works in the Sudan. This officer first came into notice by designing a scaffold which would hang six brigands simultaneously in Crete, at the time when an International Force was operating there under the command of Major General Sir Herbert Chermside.

The designing of such a scaffold seems hardly sufficient qualification for appointment as Director of Public Works in the Sudan, but he selection was justified, as Kennedy carried out some very important works and buildings in that country.

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Port Sudan.

Probably his most important work was the construction of a fine new harbour at Port Sudan on the Red Sea. As its name implies, it is *the* port of the Sudan. His Resident Engineer for this great work was Lt. Kelly, R.E., who was unfortunately killed in France in the Great War. Some idea of the size and nature of this harbour work can be given by the following few particulars :

There are five berths, each 410 feet long, which vessels run alongside.

One berth is equipped with four large electric coal transporters, delivering either direct into truck, or to a coal-distributing bridge in rear.

For general cargo, four 3-ton, and 7 ton, electric jib cranes are fitted, which can be used for cargo on any of the five berths.

A floating crane deals with loads up to 60 tons.

On the quays are four Customs' sheds.

In 1924, 699 vessels entered the port, whose total tonnage was 2½ millions, and they landed and shipped 481,000 tons of cargo.

The largest vessel that has entered the harbour had a tonnage of 27,000.

The Sudan and Egyptian Railways.

Major Girouard handed over the Sudan railways to Major Macaulay (now Sir George Macaulay) when he proceeded to take up the very important post of President of the Egyptian Railway and Harbour Board. When he left that appointment to proceed to the other parts of Africa in which we have traced his activities, Major Macaulay succeeded him in Egypt, after handing over the Sudan Railways to Captain E. C. Midwinter, R.E., under whom the system was greatly extended and improved. In this he was assisted by several R.E. Officers, among whom I would mention Newcombe, Sowerby, a very able R.E. Officer who died in Palestine during the Great War, and Russell, who recently handed over command of the Training Battalion at Chatham, in order to take up the appointment of Military Attaché in Chile.

Midwinter is now Controller of Sudan Railways in the London Office of the Sudan Government.

Blakeney, now Brigadier-General, and Clifford Hall, now Colonel, moved from the Sudan to work in the management and traffic departments respectively of the Egyptian Railways. Blakeney in due course became General Manager, and Hall, Traffic Manager. The latter is now a Director of the Anglo Egyptian Bank.

Military Works of Egyptian Army.

The military works of the Egyptian Army were in the hands of the Royal Engineers, first under Col. L. B. Friend, who was afterwards

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lights, which were constructed, trained and commanded by Major H. C. Nanton, R.E. These armoured trains used to concentrate rapidly on the section of railway line which the Boers were reported to be about to cross, and made a formidable reinforcement to the block-house defences.

RAILWAY AND TELEGRAPH WORK IN SOUTH AFRICAN WAR.

On the Railway and Telegraph systems of South Africa the R.E. had an enormous amount of work to do in the South African War, under the guidance of Lt. Col. Girouard as Director of Railways, and of Col. Hippisley as Director of Telegraphs.

RAILWAY WORK.

Lt. Colonel Girouard had to organise a transportation Staff to work in harmony with the Cape Government and Natal Government Railways, and also had to create an organisation to take over, repair, and work, the enemy's railways, as our Army advanced into the Free State, with its 400 miles of railway, and into the Transvaal with a further 900 miles, total 1,300 miles of enemy's railways.

The enemy carried out the most wholesale destruction of the railways as he retired. Of the bridges, he demolished 53 spans of 100 ft. or over, 27 spans between 75 ft. and 100 ft., and 210 spans less than 75 ft. Some of these bridges spanned deep ravines.

At most stations the water supply was destroyed, and frequently the permanent way was blown up for several miles.

Nevertheless, railway communication was opened with Johannesburg eleven days after Lord Roberts arrived there, and with Pretoria sixteen days after the Army's arrival, and with Mafeking thirteen days after its relief.

The conquered railways were repaired, staffed, and worked, partly by R.E. officers, N.C.O.'s and men; the R.E. Coys. being the 8th and 10th Rly. Coys., R.E., the 6th, 20th, 31st, and 42nd, Fortress Coys., R.E.

These were an invaluable nucleus, but their numbers were small, and the great bulk of the railway men came from various sources.

Firstly, there were the British railway employees of the Orange Free State, who left their employment on the declaration of war, and returned with us to their old posts on the railways.

In the Transvaal, however, the railway employees were all Dutch from Holland, and these declined in a body to work for us, and were deported, thus effecting a more complete and simultaneous railway strike than we have ever had in England.

Some railway men were obtained on loan from the Cape Government Railways, some were recruited in England, but a very large number of men were obtained by calling for the services of railway men who were to be found in the ranks of the Forces, particularly among the Colonial Troops.

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Several men, who had never worked on a railway, but were tired of trekking about Africa, reported themselves as expert railway men, prepared to take on any job, even driving a locomotive, or working a signal-box. These had to be weeded out and returned to their regiments, not before, however, one of these amateur engine-drivers had upset a train containing a whole Battery of Artillery into a river bed.

With this heterogeneous, but zealous, body of several thousand men, more or less expert, the working of 1,300 miles of damaged railway had to be taken over and organised.

Conspicuous in this improvised railway organisation was the Railway Pioneer Regiment, officered and recruited from the highly-skilled mining engineers and artisans of Johannesburg. The raising of this unit was initiated by a very eminent mining engineer, Mr. Seymour, who took the post of second in command as a Major. He was, unfortunately, killed in action.

To help the formation of this unit a few R.E. officers and N.C.O.'s were posted to it, three of whom have since attained considerable distinction. Lieut.-Col. Capper commanded the Railway Pioneer Regiment. He is now Lt.-General Sir John Capper. Captain E. D. Swinton was a company commander. He is now Major-General Sir Ernest Swinton, Professor of Military History at Oxford. Lt. S. H. Wilson was a company officer. He is now Brig.-General Sir Samuel Wilson, Permanent Under Secretary of State for the Colonies.

The Railway Pioneer Regiment did some magnificent work in the reconstruction of demolished railway bridges.

Among the officers who assisted Lt.-Col. Girouard to carry out this railway work were Capt. Waghorn, now Brig.-General Sir W. Danvers Waghorn, who finished his career as President of the Indian Railway Board. Major Twiss, who was afterwards Director of of Railways in France during the Great War. Major Murray, now Sir Valentine Murray. Lt. Micklem, who carried out the bulk of the rapid repair work, was wounded in the foot when De Wet raided the construction train. As he had previously been wounded in the foot at the Battle of Khartoum, General Maxwell wired to him that his feet were too big for military purposes. Lt. Stevenson was Locomotive Superintendent. He is now Major-General Stevenson, recently Chief Engineer at Aldershot. He was assisted by Lt. Newcombe and by Lt. Oakes, who is now Asst.-Director of Transportation at the War Office. Major W. S. Nathan, brother of Sir Matthew Nathan, was Staff Officer to Lt.-Col. Girouard. He is now head of the Chinese Mining Engineering Company. Lt. Leggett, now Sir Humphrey Leggett, Captains F. G. Fuller and Sewell, Lts. North, Cunnington and C. G. Fuller, and Captain H. G. de Lotbinère were also amongst the officers employed on this work.

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Lt. Manifold, now Major-General Sir Graham Bowman-Manifold, was responsible for repairing the destroyed railway telegraphs and for working them.

TELEGRAPH WORK IN SOUTH AFRICAN WAR.

While Lt.-Col. Girouard was doing this work on the railways, Lt.-Col. R. L. Hippisley was doing analogous work on the telegraph systems of South Africa. He put Capt. Fowler (now Lt.-General Sir John Fowler) in charge in the Free State. He was afterwards Director-General of Signals in France in the Great War.

Captain E. G. Godfrey-Faussett was responsible for the telegraph system of the Transvaal.

CROWN COLONY GOVERNMENT OF SOUTH AFRICA.

WORK OF R.E.

When peace was concluded in South Africa, Crown Colony Government was established in the Transvaal and Orange Free State, and these countries had to be reconstructed and administered.

In this work the Royal Engineers played a considerable part.

Sir Percy Girouard was appointed Commissioner for Railways, and kept some R.E. Officers working with him. A programme of 1,000 miles of new railway construction was put in hand.

Lt.-Col. Fowke (now Lt.-General Sir G. Fowke), who was afterwards Adjutant-General in France during the Great War, created and administered the Public Works Department of the Transvaal. In this he was assisted by Capt. R. N. Harvey, now Major-General Harvey, who is Engineer-in-Chief in India.

Colonel H. M. Jackson created and administered a Survey Department for the Transvaal and Orange Free State.

Major Leggett worked on the repatriation of the Boers.

Col. W. Peacock was Chief Engineer in South Africa after the war, and constructed large cantonments for the considerable force that was garrisoning South Africa for some years after the war.

R.E. IN SOUTH AFRICA TO-DAY.

At the present day we find the Royal Engineers still prominently represented in South Africa by Sir John Chancellor, who is Governor and Commander-in-Chief in Southern Rhodesia, having previously been Governor of Mauritius and of Trinidad.

Col. C. F. Birney is General Manager of the Rhodesian Railway system, stretching up to Katanga, in the north, and to Mashonaland in the east.

RORKE'S DRIFT.

We must not leave South Africa without referring to that very gallant feat of arms at Rorke's Drift, in Zululand, which is always associated with the name of Lt. J. R. M. Chard, R.E., and for which he was awarded the Victoria Cross.

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There had been a disaster at Isandhlwana; our force there had been wiped out by the Zulus, who then started to pour down upon Natal. Their route took them through Rorke's Drift, where Chard and Lt. Bromhead, of the South Wales Borderers, had constructed a strong defensive post. The Zulus decided to attack the post, and expected to have no difficulty in mopping it up before they went on to Natal. A terrific fight lasted for over twenty-four hours, with desperate hand to hand fighting. Thousands of Zulus were slain and they were beaten off. Discouraged by their losses, they gave up their proposed incursion into Natal. It was generally recognised that Lt. Chard's skilful and gallant defence at Rorke's Drift saved the Colony of Natal from a frightful disaster.

Captain B. L. Sclater, R.E., in Nyasaland and East Africa.

In Nyasaland, or British Central Africa, we find the work of an R.E. who played a great part in opening up Africa.

Captain Sclater, R.E., made the first road from the coast into and through Nyasaland.

I have not found any particulars of his work in Nyasaland, except that it was road work, but, when he had finished there, he moved on to East Africa to make an unmetalled road for ox transport from Mombasa to Lake Victoria Nyanza.

On that work he was assisted by Lt. G. E. Smith, R.E., better known as "Uganda Smith." He is now Brig.-General Smith, retired, and he sent me a most interesting pamphlet which he published, describing the work which Sclater and he did in the construction of this road.

The first 180 miles of road from the Coast had been made by the Imperial British East Africa Coy., and Sclater's job was to carry it 400 miles further through only partially explored country to Victoria Nyanza.

Five R.E. N.C.O.'s assisted them: Lce.-Corp. Smith, Corp. Ellis, 2nd Corp. Clarke, Lce-Corp. Simmonds, and Lce.-Corp. Brodie.

Exploring and reconnoitring for the road through all kinds of country, plains, hills, ravines, forest, bush, etc., laying out the road, and constructing bridges, were the engineering problems that confronted them, but problems of a different nature also had to be dealt with.

In 1895, British East Africa had few white people in it. Negotiations with native tribes for the supply of labour, the organising of caravans of transport to obtain food, and to supply it to the working parties; the arrangements for payment. These questions all required considerable organising and administrative talents. Captain Sclater possessed unusual powers of influencing natives and gaining their friendship and co-operation.

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Up to now, all goods have been landed in lighters and passengers in surf boats, from which they are carried ashore on the backs of natives. They embark in the same way.

Getting on to the gangway of a steamer from a surf boat can be quite an exciting experience. I once had to assist a drunken man to perform this feat. It would have been all right if he had been drunk enough to be treated like a sack of potatoes to be flung on the gangway, but unfortunately he was not. He had his own ideas as to the right moment to jump for the gangway, and the moments he selected were not the right ones.

Sir Gordon Guggisberg's Governership of the Gold Coast has been remarkable for the progress made by the Colony in that period. The mileage of motor roads has increased from 1,300 to 4,000, and of railways by 250 miles. The result is apparent in the trade and revenue. For instance, revenue has increased from 1½ millions to four millions per annum, and the bank balance from £160,000 to three millions.

Major W. E. Lees, R.E., was Director of Public Works in the Gold Coast and Northern Territories from 1904-10. As such he was responsible for the construction and maintenance of roads and building works, excluding railways and harbours.

These works included the water supply of two large towns, Accra and Sekondi, costing 1¼ millions each, town planning, Government buildings for Hospitals, Court-houses, Post-offices, Schools, Prisons, Lunatic Asylums, Police Barracks, etc.

In 1909 a special roads branch was formed under Major Leslie, R.E., with other R.E. officers under him. To-day, R.E. officers are employed on this work.

As a result of all the work that has been referred to, one can nowadays travel in West Africa by rail and road for many thousands of miles where formerly one had to walk every yard, as horses cannot live within many marches of the coast.

The most rapid mode of travel used to be in a hammock, slung fore and aft on cross bars, which rested on the heads of four natives striding along.

There was one R.E. subaltern who, when he landed in West Africa, weighed 18 stone. When the natives who were detailed to carry him in a hammock saw him they fled into the "bush," so he had to walk everywhere. Walking in West Africa is very good for the figure, but I am afraid it was not a permanent cure, as I am told that he now weighs 22 stone.

NIGERIA.

SIR GEORGE TAUBMAN-GOLDIE.

We will now travel on to Nigeria, and here we come across a very remarkable man who began his career in the Corps.

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It is entirely due to Sir George Taubman-Goldie that the enormous territory known as Nigeria belongs to the British Empire. It is an exceedingly valuable possession with great possibilities for development.

Sir G. Taubman-Goldie revived the method of Government by Chartered Company, on the precedent of the old East India Company, and Rhodes was copying Taubman-Goldie when he applied the same system to Rhodesia. Sir William Mackinnon, in East Africa, was also inspired by Taubman-Goldie's example.

It was in 1877 that he first visited the Niger Country, and by 1879 he had amalgamated all the British trading concerns on the Niger into a single company called the British Niger Company. In 1881, he applied for a charter for the company which, when granted in 1886, gave the company practically sovereign powers.

Several French trading companies were competing keenly on the Niger, but the British Company bought them out. At the same time, Goldie concluded over 400 political treaties with tribal chiefs who accepted British sovereignty.

The Germans next appeared upon the scene, and, strongly backed by Bismarck, tried to compete both in trading and in political ascendancy.

Protracted negotiations ensued with both Germany and France, throughout which Goldie was the constant adviser and watchdog alongside Lord Salisbury at the Foreign Office, and Mr. Joseph Chamberlain at the Colonial Office, and it was not till 1898 that an agreement was signed with both France and Germany which secured Nigeria to Great Britain.

Goldie governed the affairs of Nigeria from the London offices of the Niger Company which, unlike some other Chartered Companies, paid a good dividend. On January 1st, 1900, the administration of Nigeria was taken over by the Imperial Government.

In 1903-4, Goldie, at the request of the British South Africa Company, visited Rhodesia, and drew up the first scheme for the self-government of that country.

Sir Percy Girouard as Governor of Nigeria.

The next prominent Royal Engineer to whose work in Nigeria I would refer, is Sir Percy Girouard, first as High Commissioner of Northern Nigeria, and later as Governor of the whole Colony.

It was during his vigorous administration that great progress was made in developing the country, and it was entirely due to him that a great stride forward was taken in railway development by the construction of that important and economically successful line, the Baro-Kano Railway.

The Baro-Kano Railway.

This railway was mainly constructed by Royal Engineers under the

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general supervision of Mr. Eaglesome, who was Director of Railways and Public Works in Nigeria.

As you see from the map, the railway starts from Baro about 400 miles up the river Niger, to which boats with four feet draught can navigate all the year round, and runs for about 300 miles up to Kano, in Northern Nigeria, opening up a country specially suitable for cotton growing, and rich in tin. Of course, the railway facilitates the administration and development of the country. Previous to its construction all goods were transported on the heads of native carriers. The railway had been projected, and much desired, for some years before it was built, but the estimated cost had made it prohibitive. The original survey was for a railway with 1/50 ruling gradient. When Girouard arrived in Nigeria he examined the proposed route of the railway himself, and selected a better one with a ruling gradient of only 1/143 up and 1/166 down. Moreover, he guaranteed to build it for £3,000 per mile. This guarantee persuaded the Treasury to finance the line in 1907.

For its construction, Sir Percy Girouard obtained the services of three R.E. officers, Captain Mance, Lt. Maxwell and Lt. Hammond, and thirty N.C.O's and men of the 8th and 10th Railway Coys., R.E.

The work was in charge of Capt. Mance, who was afterwards head of the Railway Directorate at the War Office during the Great War.

In order to push on the work without delay railway stores and plant were shipped to Nigeria before the usual facilities for landing them at Baro had been provided. Ingenious improvisations had to be made for landing locomotives and a large tonnage of material.

Lt. Hammond was in charge of the Locomotive and Workshops Department, with Lance-Corp. Hatfield as running shed foreman, and Lance-Corp. Goddard as works' foreman.

Lt. Hammond is now Brig. General, and has for many years been specially employed by the Colonial Office to inspect and report upon Colonial railways all over Africa. He is at this moment returning from performing this duty on the railways in Iraq, and in Nyasaland. He served on a committee appointed to advise the Colonial Office as to the allocation of a loan of ten millions to various East African Colonies for railway development.

Captain Mance put Lt. Maxwell in charge of the platelaying. He is now Col. G. A. P. Maxwell, General Manager of the Railways which we took over from the Germans in Tanganyika Territory.

A record in platelaying was established by the laying of 6⅓ miles of main line and 400 yards of siding in one day, a truly wonderful performance.

Of course it must be understood that nothing like this can be done day after day, in fact their best record for 90 consecutive days was 120 miles, which gives the very satisfactory daily average over a period of three months of 1⅓ miles.

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Conspicuous in this platelaying success was Coy. Sergt.-Major Curtis. During the great War he rose to the rank of Captain. The latest news I have of him is that, in 1924, he was back in Nigeria as an Assistant Engineer on the construction of the Nigerian Eastern Railway.

The railway was completed in three years, which was much below previous estimates of time. Sir Percy Girouard had aroused the enthusiasm of every official in the Colony to co-operate in solving numerous ancillary problems, such as the supply and feeding of native labour, and the steady supply of shipping on the Niger up to Baro.

Lagos-Yebba Telegraph Line.

The first telegraph line in Nigeria from Lagos to Yebba was built by Lt. E. V. Turner, R.E., who took out 20 N.C.O's and men from Aldershot, and completed the job within a year. Later we come across Turner in charge of the Telegraph Administration of the Sudan, and he is now Colonel on the General Staff for Signals at the War Office.

The Congo.

Lieutenant W. G. Stairs, R.E.

Below the Niger we come to the Congo, which immediately recalls the name of Lt. Stairs, R.E.

He was one of the dozen white men selected by Sir H. Stanley to help him in his expedition for the rescue of Emin Pasha.

Emin Pasha had been appointed Governor of the Equatorial Province of the Sudan by Gordon, when he was Governor-General of the Sudan.

When the Mahdi rose in rebellion and captured Khartoum with his Dervishes, Emin Pasha was completely cut off, and no news came through from him. It was decided to organise an expedition to bring him out.

Sir H. Stanley was famous for his African explorations and for finding Dr. Livingstone. He was, therefore, asked to undertake the task.

Having selected a small number of men, including Stairs, to assist him, he journeyed up the Congo, which was completely unknown country, and reached Equatorial Africa, where he found Emin Pasha, and brought him out through East Africa. The expedition had thus made the first journey from west to east through the heart of Africa. They took Emin Pasha to Cairo, where his reception was so hospitable that he fell off a verandah and broke his neck.

Stairs had become so enamoured of African exploration that he resigned his commission in the British Army and accepted service under the King of the Belgians, with the mission to acquire, and develop, the Congo territory as a Belgian colony. It was mainly

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due to him that Belgium possesses that valuable country, in the acquisition of which he lost his life.

SOUTH AFRICA.

Now moving on to South Africa, we come to a large country where numerous R.E. have worked.

The earliest trace of R.E. work that I have come across is a road in Eastern Cape Colony.

The early settlers at the Cape waged intermittent frontier warfare with the Kaffirs in the neighbourhood of King Williams Town and Grahams Town. Through a "Pass" in the hills on that frontier there runs a well-graded road, which is in use to-day just as it was constructed. In the rock-cutting at the summit of the Pass there is an inscription to say that it was made by a Company of Royal Engineers in, I think, about the year 1840. I am sorry to say I have forgotten the number of the Company, but I believe it was the 42nd.

BECHUANALAND.

The Bechuanaland Protectorate was secured for the British Empire by an R.E., Colonel (afterwards General) Sir Charles Warren.

He was despatched as High Commissioner and Commander of a Force to forestall the Transvaal Boers who, under the orders of their President, Kruger, were preparing to annex Bechuanaland.

By a mixture of diplomacy and a judicious display of force, Sir Charles Warren manœuvred the Boers out of the country, and established a British Protectorate.

He had with him on this Expedition Lt. Haynes, R.E., who had previously worked with Sir Charles Warren on a dangerous secret service mission in Arabia.

CAPTAIN HAYNES IN MASHONALAND.

We next hear of Haynes in Mashonaland. In May, 1896, Captain A. E. Haynes embarked with his 43rd Fortress Coy, R.E., on the s.s. *Garth Castle*, to proceed to Mauritius for a tour of duty.

He probably thought he was about to spend some rather monotonous years in Mauritius, but the ship reached Durban just at the moment when a very serious native rising occurred in Mashonaland. A Relief Column to assist the settlers was being assembled at Beira under the orders of Colonel Alderson.

Haynes promptly took the initiative and telegraphed to G.O.C., Cape Town, suggesting that he should arm and equip the detachment of troops on board to join Col. Alderson. His detachment consisted of 4 R.A., 38 R.E., and 49 York and Lancaster Regiment.

The G.O.C. approved Capt. Haynes' suggestion. His small force landed at Beira and took part in Colonel Alderson's operations, which saved Mashonaland. Unfortunately, Haynes was killed in action storming Makoni's stronghold.

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The Corps has a permanent memorial to Captain Haynes in a medal which is competed for annually at Chatham.

The South African War.

We now come to the South African War. In the last 18 months of that war the Army in South Africa was commanded by Lord Kitchener. When he returned to England on the conclusion of the campaign, we dined him at the Chatham Mess, and I remember that in his speech he told us that, while he was carrying on the war in South Africa, the Prince of Wales (now H.M. King George V) landed at Durban, on his return voyage from Australia. Lord Kitchener went to Durban to meet him, and was greeted by the Prince of Wales with the question, " How is it that on landing at Durban I find that the Governor of Natal, Sir Henry Macallum, is an R.E., the Prime Minister of Natal, Sir Albert Hime, is an R.E., and the C.-in-C. of the Army of South Africa is an R.E."

Lord Kitchener said that he replied to the Prince of Wales by referring him to the Corps motto, "*Ubique quo Fas et Gloria ducunt.*"

General Sir Bindon Blood, whom we often see at Chatham and Aldershot looking hale and hearty, commanded a group of columns in the South African War.

Lt. Colonel Hunter-Weston (now Lt. General Sir Aylmer Hunter-Weston) was a Column Commander; also Lt. Colonel Gorringe (now Lt. General Sir George Gorringe).

The Blockhouse Lines.

The Engineer-in-Chief in the South African War was Major General Sir Elliott Wood. It devolved upon him to make practicable Lord Kitchener's blockhouse scheme, which eventually rounded up the Boer Columns.

The whole vast area of the theatre of war was divided up like a chess board, with lines of blockhouses connected by barbed wire fence. Several thousand blockhouses, and thousands of miles of barbed wire fencing, had to be rapidly erected by the organisation created by Sir Elliott Wood.

It was first necessary to settle the best type of blockhouse, suitable for rapid mass production, easy transport, and quick erection.

The Boers at this stage had lost all their artillery, so it was only necessary for the blockhouse to be bullet-proof.

Major S. R. Rice, commanding the 23rd Field Coy., R.E., who was afterwards Engineer-in-Chief in France in the Great War, evolved for this purpose the corrugated iron and shingle blockhouse, which is now in our text-book, and started with his Company the first factory for its mass production.

Armoured Trains.

On the railways these blockhouse lines were reinforced by several armoured trains, mounting machine guns, field guns, and search-

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Split bamboos make an exceedingly comfortable guard bed, and serve to keep the white man off the ground, which is important for health's sake in West Africa. The roofs of the huts were thatched with palm leaves, which were abundant in the forest.

For water supply in these prepared camps for British troops, a boiled and filtered supply was provided entirely from forest materials. Troughs, hollowed out by the natives from tree trunks, water boiled in new earthenware pots, quickly made by the native women, other pots made into filters by the insertion of a sandbag filled with charcoal freshly burnt from forest timber.

The R.E. officers and N.C.O's stationed at Sierra Leone, whose normal duty was the building of coast defences and barracks, almost invariably in the course of their tour of service, came in for one or more of such expeditions as I have been describing, *e.g.*, Mackay, G. H. Boileau (now a Chief Engineer in India), Robinson, who was killed at Tambi; Major General Gwynn, who is now Commandant of the Staff College, began his active service in this way.

COLONEL ELLIS' EXPEDITION.

Captain Sloggett, R.E., Lt. Gwynn, R.E., and two R.E. N.C.O's, proceeded with Col. Ellis' Expedition to fight the forces of a Chief called Samory, who was harrying tribes under British protection.

The French were also at war with Samory, who had been raiding their territory also.

The French and British Expeditionary Forces, starting from bases widely separated, and moving in dense forest, were unaware of each others' whereabouts, with the unfortunate result that one night they encountered each other. Both forces being under the impression that they were in contact with Samory's tribesmen, a severe action ensued, in which the British Forces suffered heavy casualties, but the French Force was wiped out.

While the respective Foreign Offices in Paris and London were engaged in clearing up this little misunderstanding, Colonel Ellis, although his carriers had bolted, proceeded to his original objective, *i.e.*, Samory's forces, and wiped them out, too.

Lt. Gwynn, who was Intelligence Officer of the Column and commanded the Advance Guard, was severely wounded.

THE FORT AT KUMASSI.

When the second Ashanti expedition took over that country in 1896, Lt. MacInnes, R.E., who was afterwards killed as a Brigadier General in France, built a Fort round the new Residency at Kumassi, which is the Capital of Ashanti.

The R.E. build a lot of forts in various parts of the world, but it is not often that they have the compliment paid to them of a full-dress siege. But MacInnes' fort at Kumassi had to stand a siege of many weeks, and held out successfully.

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In 1901, the Ashantis rose in rebellion, cut communications between Kumassi and the coast, and besieged the Governor of the Gold Coast in Kumassi Fort.

The Ashantis had got into their heads, quite erroneously, that we were trying to find and secure their golden stool. This stool they had hidden when we conquered the country, as it was the throne of their kings, and they believed it contained the soul of their nation.

We were busy with the South African War at the time, but an Expedition had to be organised to march up from the coast and relieve Kumassi; Captain R. S. McClintock, R.E., was a D.A.Q.M.G. of the relieving force. He is now G.S.O., Scottish Command.

Boundary Commissions and Survey.

The scrambling for Africa, of course, led to numerous disputes between European nations concerning the boundaries of their respective territories.

To settle thsee disputes amicably the usual procedure was to set up boundary commissions, on which R.E. officers, on account of their knowledge of survey, were always appointed, and usually an R.E. officer was in charge.

These commissions not only surveyed the boundaries, but were also required to study the whole tribal system of the country and its resources, and deal with administrative and political questions.

After the boundaries had been settled the next task was to survey the vast areas of territory acquired.

It is not possible to give the long list of boundary commissions, or the names of all the R.E. Officers who worked upon them, and who afterwards surveyed the territories, but it is safe to say that wherever you see a boundary of British territory on that map of Africa, there you see the hard work of some Royal Engineers.

About twelve thousand miles of African boundaries were delimited by Royal Engineers.

Conspicuous among these Surveying Officers, at first working in Africa, and later organising and co-ordinating the work of boundary commissions, when he was head of the Survey Branch of the War Office, and afterwards Director General of Ordnance Survey, was Captain C. F. Close, R.E., now Colonel Sir Charles Close.

Among other R.E. Officers employed on this work as subalterns, captains and majors, I will name a few: Kenny, S. C. Grant, Johnstone, O'Shea, Gillam, Woodroffe, Jackson, Watherston, Guggisberg, Gwynn, Maud, G. E. Smith, Whitlock, Austin, Jack, G. C. Williams, and many others.

Major Watherston was Director of Surveys on the Gold Coast, and afterwards was Chief Commissioner of the Northern Territory of that Colony, where he unfortunately died of blackwater fever.

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Major Guggisberg, after surveying in Gold Coast Colony, was Surveyor-General of Nigeria, with Waterhouse and Bulkeley working under him. He is now Governor of the Gold Coast.

Colonel W. G. Morris carried out the geodetic triangulation of South Africa, based on which L. C. Jackson and Winterbotham completed the survey of the Orange Free State.

In the Sudan the Survey Department was created by Colonel the Hon. M. G. Talbot, who was succeeded by Lt.-Col. Pearson, who worked for many years surveying the Sudan, and died there just as he was about to retire.

In Lower Egypt, Capt. Lyons, R.E., (now Sir Henry) was Director of Survey, Geology and Archæology. He is recognised as one of the greatest authorities on Egyptian Archæology.

One would have to continue for a very long time if one were to attempt to give a complete account of the survey work done in Africa by Royal Engineers.

It carried them as explorers over vast areas of an unknown country that had never seen a white man before.

It gave them unrivalled opportunities for big game shooting. In fact, when G. E. Smith (better known as " Uganda Smith ") first returned from British East Africa with his stories of the vast herds of every kind of big game roaming the country, his reputation for veracity was severely tried, but has since been amply vindicated.

The work led them into positions in the administration of the territories acquired. Frequently they broke off their work to take part in military operations.

Lt. Foulkes and the Emir of Kano.

For instance, when Major McD. Elliott, R.E., was in charge of the boundary commission, delimiting the Anglo-French boundary of Northern Nigeria, Sir Frederick Lugard, Governor of Nigeria, found it necessary to dispatch an expedition which was first to capture Kano, and then proceed against the Sultan of Sokoto.

Kano was captured, but the Emir of Kano escaped, and was likely to raise the tribes on the flank of the expedition when it marched on Sokoto.

Lt. Foulkes and Lt. Frith were working under Major McD. Elliott, and at that time Lt. Foulkes (who is now Chief Engineer Aldershot Command), was working detached some distance north-east of Sokoto, on the edge of the Sahara Desert. He had an escort of fourteen Hausa soldiers. No doubt the size of his small force was much exaggerated by native rumour, with the result that friendly natives near Gober, where the Emir of Kano was sheltering, sent word to Lt. Foulkes that the King of Gober was likely to side with the British, and that if Foulkes would support him with his force, he would probably hand over the Emir of Kano.

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On receipt of this information Foulkes, who had previously taken part in several West African Expeditions, mounted his servant, and a corporal, and four Hausa soldiers, on country ponies, and rode continuously for 53 hours without resting, except to water and feed the ponies. Having thus covered 175 miles, he arrived at the walled town of Gober with his servant and the Corporal. The other four had been unable to keep up.

Foulkes decided to bluff. He interviewed the King of Gober, stated he had a large force in the neighbourhood, and demanded that the Emir of Kano should be handed over to him. The King of Gober was bluffed, and handed over the Emir, whom Foulkes forthwith hustled off and delivered to Sir F. Lugard, with the result that the Expedition was not troubled by the Emir's people in the march to Sokoto.

Development of West Africa.

The survey work which has been described, of course, facilitated the development of newly acquired territories, and in this development work the R.E. played a considerable part.

The Governorship of the Gold Coast Colony has become almost a perquisite of the R.E. As Governors we have provided Sir Henry Macallum, Sir Matthew Nathan and Sir Gordon Guggisberg.

When Sir M. Nathan was Governor of the Gold Coast Colony, from 1900-1904, he caused the first railway to be built in West Africa. He found the mining concessions in chaos. For the survey of these concessions he secured Captain Watherston, R.E., with some other officers and several R.E. N.C.O's. Their valuable surveys gradually evolved order out of chaos in the concessions.

Guggisberg succeeded Watherston, and E. F. W. Lees took over from Guggisberg. C. B. O. Symons and King were among the officers thus employed.

Major Sir M. Nathan has since held several very important Government appointments, *e.g.*, Governor of Natal, and then of Hong Kong, Permanent Under Secretary of State for Ireland, and has only recently returned from being Governor of Queensland.

Watherston and Guggisberg many years ago selected a site at Takeradi Bay, where they were confident a deep water harbour could be built, but they were up against vested interests at existing landing places, and could get no backing for their scheme.

Now, however, that Sir Gordon Guggisberg is Governor of the Gold Coast, he has caused the Takaradi harbour scheme to be put in hand, and it is approaching completion. Harbour work on the West Coast of Africa is uncertain work. There is always the possibility of sand silting up, but, if the scheme proves a success, and if it becomes possible for large ships to lie alongside permanent deep water quays, Sir G. Guggisberg will have conferred a great boon on the Colony, which must increase its prosperity vastly.

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Up to now, all goods have been landed in lighters and passengers in surf boats, from which they are carried ashore on the backs of natives. They embark in the same way.

Getting on to the gangway of a steamer from a surf boat can be quite an exciting experience. I once had to assist a drunken man to perform this feat. It would have been all right if he had been drunk enough to be treated like a sack of potatoes to be flung on the gangway, but unfortunately he was not. He had his own ideas as to the right moment to jump for the gangway, and the moments he selected were not the right ones.

Sir Gordon Guggisberg's Governership of the Gold Coast has been remarkable for the progress made by the Colony in that period. The mileage of motor roads has increased from 1,300 to 4,000, and of railways by 250 miles. The result is apparent in the trade and revenue. For instance, revenue has increased from 1½ millions to four millions per annum, and the bank balance from £160,000 to three millions.

Major W. E. Lees, R.E., was Director of Public Works in the Gold Coast and Northern Territories from 1904-10. As such he was responsible for the construction and maintenance of roads and building works, excluding railways and harbours.

These works included the water supply of two large towns, Accra and Sekondi, costing 1¼ millions each, town planning, Government buildings for Hospitals, Court-houses, Post-offices, Schools, Prisons, Lunatic Asylums, Police Barracks, etc.

In 1909 a special roads branch was formed under Major Leslie, R.E., with other R.E. officers under him. To-day, R.E. officers are employed on this work.

As a result of all the work that has been referred to, one can nowadays travel in West Africa by rail and road for many thousands of miles where formerly one had to walk every yard, as horses cannot live within many marches of the coast.

The most rapid mode of travel used to be in a hammock, slung fore and aft on cross bars, which rested on the heads of four natives striding along.

There was one R.E. subaltern who, when he landed in West Africa, weighed 18 stone. When the natives who were detailed to carry him in a hammock saw him they fled into the "bush," so he had to walk everywhere. Walking in West Africa is very good for the figure, but I am afraid it was not a permanent cure, as I am told that he now weighs 22 stone.

NIGERIA.

SIR GEORGE TAUBMAN-GOLDIE.

We will now travel on to Nigeria, and here we come across a very remarkable man who began his career in the Corps.

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It is entirely due to Sir George Taubman-Goldie that the enormous territory known as Nigeria belongs to the British Empire. It is an exceedingly valuable possession with great possibilities for development.

Sir G. Taubman-Goldie revived the method of Government by Chartered Company, on the precedent of the old East India Company, and Rhodes was copying Taubman-Goldie when he applied the same system to Rhodesia. Sir William Mackinnon, in East Africa, was also inspired by Taubman-Goldie's example.

It was in 1877 that he first visited the Niger Country, and by 1879 he had amalgamated all the British trading concerns on the Niger into a single company called the British Niger Company. In 1881, he applied for a charter for the company which, when granted in 1886, gave the company practically sovereign powers.

Several French trading companies were competing keenly on the Niger, but the British Company bought them out. At the same time, Goldie concluded over 400 political treaties with tribal chiefs who accepted British sovereignty.

The Germans next appeared upon the scene, and, strongly backed by Bismarck, tried to compete both in trading and in political ascendancy.

Protracted negotiations ensued with both Germany and France, throughout which Goldie was the constant adviser and watchdog alongside Lord Salisbury at the Foreign Office, and Mr. Joseph Chamberlain at the Colonial Office, and it was not till 1898 that an agreement was signed with both France and Germany which secured Nigeria to Great Britain.

Goldie governed the affairs of Nigeria from the London offices of the Niger Company which, unlike some other Chartered Companies, paid a good dividend. On January 1st, 1900, the administration of Nigeria was taken over by the Imperial Government.

In 1903-4, Goldie, at the request of the British South Africa Company, visited Rhodesia, and drew up the first scheme for the self-government of that country.

Sir Percy Girouard as Governor of Nigeria.

The next prominent Royal Engineer to whose work in Nigeria I would refer, is Sir Percy Girouard, first as High Commissioner of Northern Nigeria, and later as Governor of the whole Colony.

It was during his vigorous administration that great progress was made in developing the country, and it was entirely due to him that a great stride forward was taken in railway development by the construction of that important and economically successful line, the Baro-Kano Railway.

The Baro-Kano Railway.

This railway was mainly constructed by Royal Engineers under the

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CONTENTS.

		PAGE
1.	SOME ROYAL ENGINEERS AND THEIR WORK IN AFRICA. (*With Map.*) By Col. Commandant H. L. Pritchard, C.B., C.M.G., D.S.O., *A.D.C.*...	194
2.	CO-OPERATION BETWEEN R.E. AND R.A.F. IN AND BEYOND INDIA. By Major A. V. Gompertz, M.C., R.E....	217
3.	ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1926. Survey on Active Service. By Captain G. F. Heaney, R.E.	225
4.	SHELL FIRE VERSUS PERMANENT FORTIFICATION. LIÈGE AND NAMUR, 1914. By Captain G. E. Grimsdale, *p.s.c.*, R.E.	237
5.	THE EFFECT OF MECHANICALIZATION OF THE ARMY ON THE ORGANISATION AND EMPLOYMENT OF DIVISIONAL AND CORPS ENGINEERS IN THE FIELD. By Major R. H. Dewing, D.S.O., M.C., R.E. ...	243
6.	MEMORIAL TO MAJOR-GENERAL WILLIAM ROY, F.R.S.	254
7.	WIDENING A RAILWAY BRIDGE. (*With Photos.*) By Lieut. R. Gardiner, R.E.	257
8.	IMPERIAL WIRELESS. (*With Maps.*) By Col. F. A. Iles, C.B.E., D.S.O. R. OF O.	259
9.	THE SHANNON HYDRO-ELECTRIC POWER DEVELOPMENT. (*With Plates and Photographs.*) By Lieutenant J. V. Jenkins, R.E.	286
10.	A RECENT DEVELOPMENT IN MECHANIZATION. By Major G. Le Q. Martel, D.S.O., M.C., R.E.	295
11.	BATTLE HONOURS OF ROYAL ENGINEER UNITS (*continued*)	301
12.	WATER DIVINING. By Lt.-Colonel Hugh Rose of Kilravock, C.M.G. (late The Black Watch)	315
13.	PULVERISED FUELFOR BOILER FIRING. (*With Plates.*) By Lieut. K. H. Tuson, R.E.	321
14.	DEMOLITION OF A MASONRY BRIDGE. (*With Plates and Photographs.*) By Captain C. G. Martin, V.C., D.S.O., R.E.	327
15.	TRADE TESTING AND TRADE TRAINING. By Capt. R. P. A. D. Lithgow, R.E.	333
16.	MAJOR-GENERAL A. EMMETT AND NAPOLEON. By F.E.G.S. ...	340
17.	MEMOIR ... ... Colonel S. H. Exham, C.B., C.B.E., late Royal Engineers. (*With Photograph.*)	345
18.	BOOKS ... ... Britain's Sea Soldiers. (By General Sir H. E. Blumberg, K.C.B., Royal Marines.) F.E.G.S. The World Crisis, 1916-1918. Parts I and II. (By The Rt. Hon. Winston S. Churchill, C.H., M.P.) H.B.-W. Governments and War, (By Major-General Sir F. Maurice, K.C.M.G., C.B.,) H.B.-W.	349

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BOOKS—(*continued*)—

Imperial Defence. (By S. King-Hall.) D.M.F.H.

Tactical Schemes. (By Lt.-Col. A. Kearsey, D.S.O., O.B.E., *p.s.c.*) N.W.N.-C.

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"Colas" Roads. G.B.O.T.

Some Books on Heating. W.B.B.

19. MAGAZINES 3

Revue Militaire Francaise. H.A.J.P.

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Bulletin Belge des Sciences Militaires. W.A.J.O'M.

Heerestechnik. F.A.I.

Militarwissenschaftliche und Technische Mitteilungen. F.A.I.

20. CORRESPONDENCE 37

Shell Fire v. Permanent Fortification. Colonel J. C. Matheson (late R.E.) 20th (Field) Company Royal Bombay S. and M. Major M. Rawlence, D.S.O. (late R.E.). Divisional Engineers. Major G. Le Q. Martel, D.S.O., M.C., R.E.

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SOME ROYAL ENGINEERS AND THEIR WORK IN AFRICA.

A LECTURE DELIVERED AT CHATHAM ON 24TH FEBRUARY, 1927.
By COL. COMMANDANT H. L. PRITCHARD, C.B., C.M.G., D.S.O., *A.D.C.*

The Lecturer's thanks are due to many R.E. Officers who sent him first hand nformation about the work described in this lecture.

INTRODUCTION.

In this lecture I want to describe the great *variety* of the opportunities, the work, and the achievements of some Royal Engineers in Africa during the last thirty to forty years.

That work, and those achievements, have helped in great measure to open up a vast continent, which, forty years ago, was practically closed and unknown.

I have said that I am going to refer to the work of *some* Royal Engineers, because, in a lecture of one hour, it is impossible to deal exhaustively with the work of all the R.E's. who have laboured in Africa, or to name them all.

THE SCRAMBLE FOR AFRICA.

Here we have a map of Africa, which the Survey School kindly prepared for this lecture.

On that map you see the boundaries of the territories of various European nations clearly marked.

But thirty to forty years ago the map of Africa was a very different thing.

Up to that time European nations had in most parts of Africa contented themselves with trading stations on the sea coast, to which the natives from the Hinterland brought their produce to exchange for European goods.

This happy-go-lucky arrangement gave place to what has been called "The Scramble for Africa." The French began it. They started to go into the hinterland of their coastal settlements on the West Coast, making treaties with native chiefs to accept, first, French protection, and then sovereignty.

We soon discovered that unless we did the same thing the French would divert the whole trade in the hinterland of our coastal trading stations to theirs. Consequently we set about securing the allegiance of the tribes behind our settlements.

The Germans were late in joining in the scramble. By the time they took a hand in it the British and French had secured most of

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the best territory, but the Germans elbowed their way in, and we were all engaged in pegging out claims to territory by making treaties with native chiefs.

MILITARY EXPEDITIONS IN WEST AFRICA.

This scramble for Africa somewhat bewildered the native chiefs. Their tribes were nearly always at war with each other, so that many of them welcomed the protection offered by a European Power, and were quick to claim protection when attacked.

Other tribes, however, resented the arrival of the white man, and made war upon him.

These were the causes of numerous military Expeditions, particularly in West Africa, on which the R.E. were well represented.

The expeditions were nearly always organised entirely with West African or West Indian Troops, led by British officers, but in a few cases small bodies of British troops were employed, notably in Lord Wolseley's expedition to Ashanti in 1875, again in the second Ashanti expedition of 1895, and in the suppression of the Ashanti rebellion in 1901.

In West Africa these expeditions travelled usually through dense primeval forest of enormous trees running up to 200 ft. in height, with thick undergrowth and swamps below them, all interlaced with forest creepers. In such forests the sun is never seen, except in village clearings.

To penetrate this forest one must either use native tracks, which become overgrown with extraordinary rapidity directly they fall into disuse, or else one must cut every foot of one's way.

TACTICS OF "BUSH" FIGHTING.

In this sort of country, commonly called "Bush," the tactics of bush fighting do not vary much.

A column on the march has to proceed in single file, all food, and ammunition, and stores, being carried in 50lb loads on the heads of native carriers.

These carriers, though willing to do this duty, have no desire to be involved in fighting, and usually fling down their loads and disappear directly there is any sign of it.

To stop such a single-file column the hostile natives usually built a series of stockades at intervals across the path, and they would construct, and very cleverly camouflage our old friend the "deep military pit," complete with pointed stakes, but they improved upon our specification for this pit, by putting poison on the business end of the pointed stakes.

On either side of the path approaching the stockade, parties would lie in ambush.

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The leading files of the column usually suffered when they came upon these stockades round a bend in the path. It was impossible to march with flank guards laboriously cutting their way through every foot of the forest on either side of the path.

Having, however, found the stockade and ambushes by the system of "trial and error," the normal procedure to overcome the defence was for those who were not thus engaged at a disadvantage in the vanguard, to cut their way into the forest on either side to turn both flanks of ambushes and of stockade.

The defenders usually fled when the flanks were turned. The stockades did not run far to either side of the path. If they did not fly at once the fighting was at any rate on equal terms, in which the white man's leading gained the day.

The stockade then had to be cleared away, or a path cut round it, and the column resumed its march, to repeat the procedure at the next stockade.

Eventually a village would be reached, protected by an extremely strong stockade, often formed of growing trees. Here the R.E. would be called upon to blow a breach.

Lt. W. H. Robinson, R.E., who blew up numerous stockades successfully, was eventually killed at a stockade at a place called Tembé.

R.E. Work on West African Expeditions.

Besides demolitions, the R.E. were required on mapping, telegraph laying, bridging, water supply and hutting.

As maps did not exist, it was the duty of the R.E. to map the route followed by the expedition, by route traverse and sextant observations for latitude. Chronometers were not usually available.

As regards the bridging of rivers for single file traffic, this was done either by the local inhabitants, or by bridging parties of natives marching with the column. The natives were very expert at the work, but it was the business of the R. E. to get them on to it.

The usual method was to cut forked trees at the river bank and use them as the uprights of pile trestles forced by hand into the sandy river bed. The transoms rested in these forks. Roadbearers, also cut at the river bank, were lashed to transoms by creepers torn from the trees and a corduroy roadway similarly lashed on to the roadbearers.

When British troops accompanied the expedition, as in the invasion of Ashanti, the R.E. had more work to do. In the expedition of which Major Sinclair was the C.R.E., the British were not landed until an advance guard of native scouts, organised by Major Baden-Powell, backed by native troops, had penetrated several marches inland.

Behind this screen, hutted camps of bamboo huts were put up for the British at the end of each day's march.

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Split bamboos make an exceedingly comfortable guard bed, and serve to keep the white man off the ground, which is important for health's sake in West Africa. The roofs of the huts were thatched with palm leaves, which were abundant in the forest.

For water supply in these prepared camps for British troops, a boiled and filtered supply was provided entirely from forest materials. Troughs, hollowed out by the natives from tree trunks, water boiled in new earthenware pots, quickly made by the native women, other pots made into filters by the insertion of a sandbag filled with charcoal freshly burnt from forest timber.

The R.E. officers and N.C.O's stationed at Sierra Leone, whose normal duty was the building of coast defences and barracks, almost invariably in the course of their tour of service, came in for one or more of such expeditions as I have been describing, *e.g.*, Mackay, G. H. Boileau (now a Chief Engineer in India), Robinson, who was killed at Tambi; Major General Gwynn, who is now Commandant of the Staff College, began his active service in this way.

COLONEL ELLIS' EXPEDITION.

Captain Sloggett, R.E., Lt. Gwynn, R.E., and two R.E. N.C.O's, proceeded with Col. Ellis' Expedition to fight the forces of a Chief called Samory, who was harrying tribes under British protection.

The French were also at war with Samory, who had been raiding their territory also.

The French and British Expeditionary Forces, starting from bases widely separated, and moving in dense forest, were unaware of each others' whereabouts, with the unfortunate result that one night they encountered each other. Both forces being under the impression that they were in contact with Samory's tribesmen, a severe action ensued, in which the British Forces suffered heavy casualties, but the French Force was wiped out.

While the respective Foreign Offices in Paris and London were engaged in clearing up this little misunderstanding, Colonel Ellis, although his carriers had bolted, proceeded to his original objective, *i.e.*, Samory's forces, and wiped them out, too.

Lt. Gwynn, who was Intelligence Officer of the Column and commanded the Advance Guard, was severely wounded.

THE FORT AT KUMASSI.

When the second Ashanti expedition took over that country in 1896, Lt. MacInnes, R.E., who was afterwards killed as a Brigadier General in France, built a Fort round the new Residency at Kumassi, which is the Capital of Ashanti.

The R.E. build a lot of forts in various parts of the world, but it is not often that they have the compliment paid to them of a full-dress siege. But MacInnes' fort at Kumassi had to stand a siege of many weeks, and held out successfully.

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In 1901, the Ashantis rose in rebellion, cut communications between Kumassi and the coast, and besieged the Governor of the Gold Coast in Kumassi Fort.

The Ashantis had got into their heads, quite erroneously, that we were trying to find and secure their golden stool. This stool they had hidden when we conquered the country, as it was the throne of their kings, and they believed it contained the soul of their nation.

We were busy with the South African War at the time, but an Expedition had to be organised to march up from the coast and relieve Kumassi; Captain R. S. McClintock, R.E., was a D.A.Q.M.G. of the relieving force. He is now G.S.O., Scottish Command.

Boundary Commissions and Survey.

The scrambling for Africa, of course, led to numerous disputes between European nations concerning the boundaries of their respective territories.

To settle thsee disputes amicably the usual procedure was to set up boundary commissions, on which R.E. officers, on account of their knowledge of survey, were always appointed, and usually an R.E. officer was in charge.

These commissions not only surveyed the boundaries, but were also required to study the whole tribal system of the country and its resources, and deal with administrative and political questions.

After the boundaries had been settled the next task was to survey the vast areas of territory acquired.

It is not possible to give the long list of boundary commissions, or the names of all the R.E. Officers who worked upon them, and who afterwards surveyed the territories, but it is safe to say that wherever you see a boundary of British territory on that map of Africa, there you see the hard work of some Royal Engineers.

About twelve thousand miles of African boundaries were delimited by Royal Engineers.

Conspicuous among these Surveying Officers, at first working in Africa, and later organising and co-ordinating the work of boundary commissions, when he was head of the Survey Branch of the War Office, and afterwards Director General of Ordnance Survey, was Captain C. F. Close, R.E., now Colonel Sir Charles Close.

Among other R.E. Officers employed on this work as subalterns, captains and majors, I will name a few: Kenny, S. C. Grant, Johnstone, O'Shea, Gillam, Woodroffe, Jackson, Watherston, Guggisberg, Gwynn, Maud, G. E. Smith, Whitlock, Austin, Jack, G. C. Williams, and many others.

Major Watherston was Director of Surveys on the Gold Coast, and afterwards was Chief Commissioner of the Northern Territory of that Colony, where he unfortunately died of blackwater fever.

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Major Guggisberg, after surveying in Gold Coast Colony, was Surveyor-General of Nigeria, with Waterhouse and Bulkeley working under him. He is now Governor of the Gold Coast.

Colonel W. G. Morris carried out the geodetic triangulation of South Africa, based on which L. C. Jackson and Winterbotham completed the survey of the Orange Free State.

In the Sudan the Survey Department was created by Colonel the Hon. M. G. Talbot, who was succeeded by Lt.-Col. Pearson, who worked for many years surveying the Sudan, and died there just as he was about to retire.

In Lower Egypt, Capt. Lyons, R.E., (now Sir Henry) was Director of Survey, Geology and Archæology. He is recognised as one of the greatest authorities on Egyptian Archæology.

One would have to continue for a very long time if one were to attempt to give a complete account of the survey work done in Africa by Royal Engineers.

It carried them as explorers over vast areas of an unknown country that had never seen a white man before.

It gave them unrivalled opportunities for big game shooting. In fact, when G. E. Smith (better known as " Uganda Smith ") first returned from British East Africa with his stories of the vast herds of every kind of big game roaming the country, his reputation for veracity was severely tried, but has since been amply vindicated.

The work led them into positions in the administration of the territories acquired. Frequently they broke off their work to take part in military operations.

Lt. Foulkes and the Emir of Kano.

For instance, when Major McD. Elliott, R.E., was in charge of the boundary commission, delimiting the Anglo-French boundary of Northern Nigeria, Sir Frederick Lugard, Governor of Nigeria, found it necessary to dispatch an expedition which was first to capture Kano, and then proceed against the Sultan of Sokoto.

Kano was captured, but the Emir of Kano escaped, and was likely to raise the tribes on the flank of the expedition when it marched on Sokoto.

Lt. Foulkes and Lt. Frith were working under Major McD. Elliott, and at that time Lt. Foulkes (who is now Chief Engineer Aldershot Command), was working detached some distance north-east of Sokoto, on the edge of the Sahara Desert. He had an escort of fourteen Hausa soldiers. No doubt the size of his small force was much exaggerated by native rumour, with the result that friendly natives near Gober, where the Emir of Kano was sheltering, sent word to Lt. Foulkes that the King of Gober was likely to side with the British, and that if Foulkes would support him with his force, he would probably hand over the Emir of Kano.

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On receipt of this information Foulkes, who had previously taken part in several West African Expeditions, mounted his servant, and a corporal, and four Hausa soldiers, on country ponies, and rode continuously for 53 hours without resting, except to water and feed the ponies. Having thus covered 175 miles, he arrived at the walled town of Gober with his servant and the Corporal. The other four had been unable to keep up.

Foulkes decided to bluff. He interviewed the King of Gober, stated he had a large force in the neighbourhood, and demanded that the Emir of Kano should be handed over to him. The King of Gober was bluffed, and handed over the Emir, whom Foulkes forthwith hustled off and delivered to Sir F. Lugard, with the result that the Expedition was not troubled by the Emir's people in the march to Sokoto.

Development of West Africa.

The survey work which has been described, of course, facilitated the development of newly acquired territories, and in this development work the R.E. played a considerable part.

The Governorship of the Gold Coast Colony has become almost a perquisite of the R.E. As Governors we have provided Sir Henry Macallum, Sir Matthew Nathan and Sir Gordon Guggisberg.

When Sir M. Nathan was Governor of the Gold Coast Colony, from 1900-1904, he caused the first railway to be built in West Africa. He found the mining concessions in chaos. For the survey of these concessions he secured Captain Watherston, R.E., with some other officers and several R.E. N.C.O's. Their valuable surveys gradually evolved order out of chaos in the concessions.

Guggisberg succeeded Watherston, and E. F. W. Lees took over from Guggisberg. C. B. O. Symons and King were among the officers thus employed.

Major Sir M. Nathan has since held several very important Government appointments, *e.g.*, Governor of Natal, and then of Hong Kong, Permanent Under Secretary of State for Ireland, and has only recently returned from being Governor of Queensland.

Watherston and Guggisberg many years ago selected a site at Takeradi Bay, where they were confident a deep water harbour could be built, but they were up against vested interests at existing landing places, and could get no backing for their scheme.

Now, however, that Sir Gordon Guggisberg is Governor of the Gold Coast, he has caused the Takaradi harbour scheme to be put in hand, and it is approaching completion. Harbour work on the West Coast of Africa is uncertain work. There is always the possibility of sand silting up, but, if the scheme proves a success, and if it becomes possible for large ships to lie alongside permanent deep water quays, Sir G. Guggisberg will have conferred a great boon on the Colony, which must increase its prosperity vastly.

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Up to now, all goods have been landed in lighters and passengers in surf boats, from which they are carried ashore on the backs of natives. They embark in the same way.

Getting on to the gangway of a steamer from a surf boat can be quite an exciting experience. I once had to assist a drunken man to perform this feat. It would have been all right if he had been drunk enough to be treated like a sack of potatoes to be flung on the gangway, but unfortunately he was not. He had his own ideas as to the right moment to jump for the gangway, and the moments he selected were not the right ones.

Sir Gordon Guggisberg's Governership of the Gold Coast has been remarkable for the progress made by the Colony in that period. The mileage of motor roads has increased from 1,300 to 4,000, and of railways by 250 miles. The result is apparent in the trade and revenue. For instance, revenue has increased from 1½ millions to four millions per annum, and the bank balance from £160,000 to three millions.

Major W. E. Lees, R.E., was Director of Public Works in the Gold Coast and Northern Territories from 1904-10. As such he was responsible for the construction and maintenance of roads and building works, excluding railways and harbours.

These works included the water supply of two large towns, Accra and Sekondi, costing 1¼ millions each, town planning, Government buildings for Hospitals, Court-houses, Post-offices, Schools, Prisons, Lunatic Asylums, Police Barracks, etc.

In 1909 a special roads branch was formed under Major Leslie, R.E., with other R.E. officers under him. To-day, R.E. officers are employed on this work.

As a result of all the work that has been referred to, one can nowadays travel in West Africa by rail and road for many thousands of miles where formerly one had to walk every yard, as horses cannot live within many marches of the coast.

The most rapid mode of travel used to be in a hammock, slung fore and aft on cross bars, which rested on the heads of four natives striding along.

There was one R.E. subaltern who, when he landed in West Africa, weighed 18 stone. When the natives who were detailed to carry him in a hammock saw him they fled into the "bush," so he had to walk everywhere. Walking in West Africa is very good for the figure, but I am afraid it was not a permanent cure, as I am told that he now weighs 22 stone.

NIGERIA.

SIR GEORGE TAUBMAN-GOLDIE.

We will now travel on to Nigeria, and here we come across a very remarkable man who began his career in the Corps.

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It is entirely due to Sir George Taubman-Goldie that the enormous territory known as Nigeria belongs to the British Empire. It is an exceedingly valuable possession with great possibilities for development.

Sir G. Taubman-Goldie revived the method of Government by Chartered Company, on the precedent of the old East India Company, and Rhodes was copying Taubman-Goldie when he applied the same system to Rhodesia. Sir William Mackinnon, in East Africa, was also inspired by Taubman-Goldie's example.

It was in 1877 that he first visited the Niger Country, and by 1879 he had amalgamated all the British trading concerns on the Niger into a single company called the British Niger Company. In 1881, he applied for a charter for the company which, when granted in 1886, gave the company practically sovereign powers.

Several French trading companies were competing keenly on the Niger, but the British Company bought them out. At the same time, Goldie concluded over 400 political treaties with tribal chiefs who accepted British sovereignty.

The Germans next appeared upon the scene, and, strongly backed by Bismarck, tried to compete both in trading and in political ascendancy.

Protracted negotiations ensued with both Germany and France, throughout which Goldie was the constant adviser and watchdog alongside Lord Salisbury at the Foreign Office, and Mr. Joseph Chamberlain at the Colonial Office, and it was not till 1898 that an agreement was signed with both France and Germany which secured Nigeria to Great Britain.

Goldie governed the affairs of Nigeria from the London offices of the Niger Company which, unlike some other Chartered Companies, paid a good dividend. On January 1st, 1900, the administration of Nigeria was taken over by the Imperial Government.

In 1903-4, Goldie, at the request of the British South Africa Company, visited Rhodesia, and drew up the first scheme for the self-government of that country.

Sir Percy Girouard as Governor of Nigeria.

The next prominent Royal Engineer to whose work in Nigeria I would refer, is Sir Percy Girouard, first as High Commissioner of Northern Nigeria, and later as Governor of the whole Colony.

It was during his vigorous administration that great progress was made in developing the country, and it was entirely due to him that a great stride forward was taken in railway development by the construction of that important and economically successful line, the Baro-Kano Railway.

The Baro-Kano Railway.

This railway was mainly constructed by Royal Engineers under the

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general supervision of Mr. Eaglesome, who was Director of Railways and Public Works in Nigeria.

As you see from the map, the railway starts from Baro about 400 miles up the river Niger, to which boats with four feet draught can navigate all the year round, and runs for about 300 miles up to Kano, in Northern Nigeria, opening up a country specially suitable for cotton growing, and rich in tin. Of course, the railway facilitates the administration and development of the country. Previous to its construction all goods were transported on the heads of native carriers. The railway had been projected, and much desired, for some years before it was built, but the estimated cost had made it prohibitive. The original survey was for a railway with 1/50 ruling gradient. When Girouard arrived in Nigeria he examined the proposed route of the railway himself, and selected a better one with a ruling gradient of only 1/143 up and 1/166 down. Moreover, he guaranteed to build it for £3,000 per mile. This guarantee persuaded the Treasury to finance the line in 1907.

For its construction, Sir Percy Girouard obtained the services of three R.E. officers, Captain Mance, Lt. Maxwell and Lt. Hammond, and thirty N.C.O's and men of the 8th and 10th Railway Coys., R.E.

The work was in charge of Capt. Mance, who was afterwards head of the Railway Directorate at the War Office during the Great War.

In order to push on the work without delay railway stores and plant were shipped to Nigeria before the usual facilities for landing them at Baro had been provided. Ingenious improvisations had to be made for landing locomotives and a large tonnage of material.

Lt. Hammond was in charge of the Locomotive and Workshops Department, with Lance-Corp. Hatfield as running shed foreman, and Lance-Corp. Goddard as works' foreman.

Lt. Hammond is now Brig. General, and has for many years been specially employed by the Colonial Office to inspect and report upon Colonial railways all over Africa. He is at this moment returning from performing this duty on the railways in Iraq, and in Nyasaland. He served on a committee appointed to advise the Colonial Office as to the allocation of a loan of ten millions to various East African Colonies for railway development.

Captain Mance put Lt. Maxwell in charge of the platelaying. He is now Col. G. A. P. Maxwell, General Manager of the Railways which we took over from the Germans in Tanganyika Territory.

A record in platelaying was established by the laying of 6⅓ miles of main line and 400 yards of siding in one day, a truly wonderful performance.

Of course it must be understood that nothing like this can be done day after day, in fact their best record for 90 consecutive days was 120 miles, which gives the very satisfactory daily average over a period of three months of 1⅓ miles.

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Conspicuous in this platelaying success was Coy. Sergt.-Major Curtis. During the great War he rose to the rank of Captain. The latest news I have of him is that, in 1924, he was back in Nigeria as an Assistant Engineer on the construction of the Nigerian Eastern Railway.

The railway was completed in three years, which was much below previous estimates of time. Sir Percy Girouard had aroused the enthusiasm of every official in the Colony to co-operate in solving numerous ancillary problems, such as the supply and feeding of native labour, and the steady supply of shipping on the Niger up to Baro.

Lagos-Yebba Telegraph Line.

The first telegraph line in Nigeria from Lagos to Yebba was built by Lt. E. V. Turner, R.E., who took out 20 N.C.O's and men from Aldershot, and completed the job within a year. Later we come across Turner in charge of the Telegraph Administration of the Sudan, and he is now Colonel on the General Staff for Signals at the War Office.

The Congo.

Lieutenant W. G. Stairs, R.E.

Below the Niger we come to the Congo, which immediately recalls the name of Lt. Stairs, R.E.

He was one of the dozen white men selected by Sir H. Stanley to help him in his expedition for the rescue of Emin Pasha.

Emin Pasha had been appointed Governor of the Equatorial Province of the Sudan by Gordon, when he was Governor-General of the Sudan.

When the Mahdi rose in rebellion and captured Khartoum with his Dervishes, Emin Pasha was completely cut off, and no news came through from him. It was decided to organise an expedition to bring him out.

Sir H. Stanley was famous for his African explorations and for finding Dr. Livingstone. He was, therefore, asked to undertake the task.

Having selected a small number of men, including Stairs, to assist him, he journeyed up the Congo, which was completely unknown country, and reached Equatorial Africa, where he found Emin Pasha, and brought him out through East Africa. The expedition had thus made the first journey from west to east through the heart of Africa. They took Emin Pasha to Cairo, where his reception was so hospitable that he fell off a verandah and broke his neck.

Stairs had become so enamoured of African exploration that he resigned his commission in the British Army and accepted service under the King of the Belgians, with the mission to acquire, and develop, the Congo territory as a Belgian colony. It was mainly

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due to him that Belgium possesses that valuable country, in the acquisition of which he lost his life.

SOUTH AFRICA.

Now moving on to South Africa, we come to a large country where numerous R.E. have worked.

The earliest trace of R.E. work that I have come across is a road in Eastern Cape Colony.

The early settlers at the Cape waged intermittent frontier warfare with the Kaffirs in the neighbourhood of King Williams Town and Grahams Town. Through a "Pass" in the hills on that frontier there runs a well-graded road, which is in use to-day just as it was constructed. In the rock-cutting at the summit of the Pass there is an inscription to say that it was made by a Company of Royal Engineers in, I think, about the year 1840. I am sorry to say I have forgotten the number of the Company, but I believe it was the 42nd.

BECHUANALAND.

The Bechuanaland Protectorate was secured for the British Empire by an R.E., Colonel (afterwards General) Sir Charles Warren.

He was despatched as High Commissioner and Commander of a Force to forestall the Transvaal Boers who, under the orders of their President, Kruger, were preparing to annex Bechuanaland.

By a mixture of diplomacy and a judicious display of force, Sir Charles Warren manœuvred the Boers out of the country, and established a British Protectorate.

He had with him on this Expedition Lt. Haynes, R.E., who had previously worked with Sir Charles Warren on a dangerous secret service mission in Arabia.

CAPTAIN HAYNES IN MASHONALAND.

We next hear of Haynes in Mashonaland. In May, 1896, Captain A. E. Haynes embarked with his 43rd Fortress Coy, R.E., on the s.s. *Garth Castle*, to proceed to Mauritius for a tour of duty.

He probably thought he was about to spend some rather monotonous years in Mauritius, but the ship reached Durban just at the moment when a very serious native rising occurred in Mashonaland. A Relief Column to assist the settlers was being assembled at Beira under the orders of Colonel Alderson.

Haynes promptly took the initiative and telegraphed to G.O.C., Cape Town, suggesting that he should arm and equip the detachment of troops on board to join Col. Alderson. His detachment consisted of 4 R.A., 38 R.E., and 49 York and Lancaster Regiment.

The G.O.C. approved Capt. Haynes' suggestion. His small force landed at Beira and took part in Colonel Alderson's operations, which saved Mashonaland. Unfortunately, Haynes was killed in action storming Makoni's stronghold.

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The Corps has a permanent memorial to Captain Haynes in a medal which is competed for annually at Chatham.

The South African War.

We now come to the South African War. In the last 18 months of that war the Army in South Africa was commanded by Lord Kitchener. When he returned to England on the conclusion of the campaign, we dined him at the Chatham Mess, and I remember that in his speech he told us that, while he was carrying on the war in South Africa, the Prince of Wales (now H.M. King George V) landed at Durban, on his return voyage from Australia. Lord Kitchener went to Durban to meet him, and was greeted by the Prince of Wales with the question, " How is it that on landing at Durban I find that the Governor of Natal, Sir Henry Macallum, is an R.E., the Prime Minister of Natal, Sir Albert Hime, is an R.E., and the C.-in-C. of the Army of South Africa is an R.E."

Lord Kitchener said that he replied to the Prince of Wales by referring him to the Corps motto, "*Ubique quo Fas et Gloria ducunt.*"

General Sir Bindon Blood, whom we often see at Chatham and Aldershot looking hale and hearty, commanded a group of columns in the South African War.

Lt. Colonel Hunter-Weston (now Lt. General Sir Aylmer Hunter-Weston) was a Column Commander; also Lt. Colonel Gorringe (now Lt. General Sir George Gorringe).

The Blockhouse Lines.

The Engineer-in-Chief in the South African War was Major General Sir Elliott Wood. It devolved upon him to make practicable Lord Kitchener's blockhouse scheme, which eventually rounded up the Boer Columns.

The whole vast area of the theatre of war was divided up like a chess board, with lines of blockhouses connected by barbed wire fence. Several thousand blockhouses, and thousands of miles of barbed wire fencing, had to be rapidly erected by the organisation created by Sir Elliott Wood.

It was first necessary to settle the best type of blockhouse, suitable for rapid mass production, easy transport, and quick erection.

The Boers at this stage had lost all their artillery, so it was only necessary for the blockhouse to be bullet-proof.

Major S. R. Rice, commanding the 23rd Field Coy., R.E., who was afterwards Engineer-in-Chief in France in the Great War, evolved for this purpose the corrugated iron and shingle blockhouse, which is now in our text-book, and started with his Company the first factory for its mass production.

Armoured Trains.

On the railways these blockhouse lines were reinforced by several armoured trains, mounting machine guns, field guns, and search-

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lights, which were constructed, trained and commanded by Major H. C. Nanton, R.E. These armoured trains used to concentrate rapidly on the section of railway line which the Boers were reported to be about to cross, and made a formidable reinforcement to the block-house defences.

RAILWAY AND TELEGRAPH WORK IN SOUTH AFRICAN WAR.

On the Railway and Telegraph systems of South Africa the R.E. had an enormous amount of work to do in the South African War, under the guidance of Lt. Col. Girouard as Director of Railways, and of Col. Hippisley as Director of Telegraphs.

RAILWAY WORK.

Lt. Colonel Girouard had to organise a transportation Staff to work in harmony with the Cape Government and Natal Government Railways, and also had to create an organisation to take over, repair, and work, the enemy's railways, as our Army advanced into the Free State, with its 400 miles of railway, and into the Transvaal with a further 900 miles, total 1,300 miles of enemy's railways.

The enemy carried out the most wholesale destruction of the railways as he retired. Of the bridges, he demolished 53 spans of 100 ft. or over, 27 spans between 75 ft. and 100 ft., and 210 spans less than 75 ft. Some of these bridges spanned deep ravines.

At most stations the water supply was destroyed, and frequently the permanent way was blown up for several miles.

Nevertheless, railway communication was opened with Johannesburg eleven days after Lord Roberts arrived there, and with Pretoria sixteen days after the Army's arrival, and with Mafeking thirteen days after its relief.

The conquered railways were repaired, staffed, and worked, partly by R.E. officers, N.C.O.'s and men; the R.E. Coys. being the 8th and 10th Rly. Coys., R.E., the 6th, 20th, 31st, and 42nd, Fortress Coys., R.E.

These were an invaluable nucleus, but their numbers were small, and the great bulk of the railway men came from various sources.

Firstly, there were the British railway employees of the Orange Free State, who left their employment on the declaration of war, and returned with us to their old posts on the railways.

In the Transvaal, however, the railway employees were all Dutch from Holland, and these declined in a body to work for us, and were deported, thus effecting a more complete and simultaneous railway strike than we have ever had in England.

Some railway men were obtained on loan from the Cape Government Railways, some were recruited in England, but a very large number of men were obtained by calling for the services of railway men who were to be found in the ranks of the Forces, particularly among the Colonial Troops.

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Several men, who had never worked on a railway, but were tired of trekking about Africa, reported themselves as expert railway men, prepared to take on any job, even driving a locomotive, or working a signal-box. These had to be weeded out and returned to their regiments, not before, however, one of these amateur engine-drivers had upset a train containing a whole Battery of Artillery into a river bed.

With this heterogeneous, but zealous, body of several thousand men, more or less expert, the working of 1,300 miles of damaged railway had to be taken over and organised.

Conspicuous in this improvised railway organisation was the Railway Pioneer Regiment, officered and recruited from the highly-skilled mining engineers and artisans of Johannesburg. The raising of this unit was initiated by a very eminent mining engineer, Mr. Seymour, who took the post of second in command as a Major. He was, unfortunately, killed in action.

To help the formation of this unit a few R.E. officers and N.C.O.'s were posted to it, three of whom have since attained considerable distinction. Lieut.-Col. Capper commanded the Railway Pioneer Regiment. He is now Lt.-General Sir John Capper. Captain E. D. Swinton was a company commander. He is now Major-General Sir Ernest Swinton, Professor of Military History at Oxford. Lt. S. H. Wilson was a company officer. He is now Brig.-General Sir Samuel Wilson, Permanent Under Secretary of State for the Colonies.

The Railway Pioneer Regiment did some magnificent work in the reconstruction of demolished railway bridges.

Among the officers who assisted Lt.-Col. Girouard to carry out this railway work were Capt. Waghorn, now Brig.-General Sir W. Danvers Waghorn, who finished his career as President of the Indian Railway Board. Major Twiss, who was afterwards Director of of Railways in France during the Great War. Major Murray, now Sir Valentine Murray. Lt. Micklem, who carried out the bulk of the rapid repair work, was wounded in the foot when De Wet raided the construction train. As he had previously been wounded in the foot at the Battle of Khartoum, General Maxwell wired to him that his feet were too big for military purposes. Lt. Stevenson was Locomotive Superintendent. He is now Major-General Stevenson, recently Chief Engineer at Aldershot. He was assisted by Lt. Newcombe and by Lt. Oakes, who is now Asst.-Director of Transportation at the War Office. Major W. S. Nathan, brother of Sir Matthew Nathan, was Staff Officer to Lt.-Col. Girouard. He is now head of the Chinese Mining Engineering Company. Lt. Leggett, now Sir Humphrey Leggett, Captains F. G. Fuller and Sewell, Lts. North, Cunnington and C. G. Fuller, and Captain H. G. de Lotbinière were also amongst the officers employed on this work.

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Lt. Manifold, now Major-General Sir Graham Bowman-Manifold, was responsible for repairing the destroyed railway telegraphs and for working them.

TELEGRAPH WORK IN SOUTH AFRICAN WAR.

While Lt.-Col. Girouard was doing this work on the railways, Lt.-Col. R. L. Hippisley was doing analogous work on the telegraph systems of South Africa. He put Capt. Fowler (now Lt.-General Sir John Fowler) in charge in the Free State. He was afterwards Director-General of Signals in France in the Great War.

Captain E. G. Godfrey-Faussett was responsible for the telegraph system of the Transvaal.

CROWN COLONY GOVERNMENT OF SOUTH AFRICA.

WORK OF R.E.

When peace was concluded in South Africa, Crown Colony Government was established in the Transvaal and Orange Free State, and these countries had to be reconstructed and administered.

In this work the Royal Engineers played a considerable part.

Sir Percy Girouard was appointed Commissioner for Railways, and kept some R.E. Officers working with him. A programme of 1,000 miles of new railway construction was put in hand.

Lt.-Col. Fowke (now Lt.-General Sir G. Fowke), who was afterwards Adjutant-General in France during the Great War, created and administered the Public Works Department of the Transvaal. In this he was assisted by Capt. R. N. Harvey, now Major-General Harvey, who is Engineer-in-Chief in India.

Colonel H. M. Jackson created and administered a Survey Department for the Transvaal and Orange Free State.

Major Leggett worked on the repatriation of the Boers.

Col. W. Peacock was Chief Engineer in South Africa after the war, and constructed large cantonments for the considerable force that was garrisoning South Africa for some years after the war.

R.E. IN SOUTH AFRICA TO-DAY.

At the present day we find the Royal Engineers still prominently represented in South Africa by Sir John Chancellor, who is Governor and Commander-in-Chief in Southern Rhodesia, having previously been Governor of Mauritius and of Trinidad.

Col. C. F. Birney is General Manager of the Rhodesian Railway system, stretching up to Katanga, in the north, and to Mashonaland in the east.

RORKE'S DRIFT.

We must not leave South Africa without referring to that very gallant feat of arms at Rorke's Drift, in Zululand, which is always associated with the name of Lt. J. R. M. Chard, R.E., and for which he was awarded the Victoria Cross.

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There had been a disaster at Isandhlwana; our force there had been wiped out by the Zulus, who then started to pour down upon Natal. Their route took them through Rorke's Drift, where Chard and Lt. Bromhead, of the South Wales Borderers, had constructed a strong defensive post. The Zulus decided to attack the post, and expected to have no difficulty in mopping it up before they went on to Natal. A terrific fight lasted for over twenty-four hours, with desperate hand to hand fighting. Thousands of Zulus were slain and they were beaten off. Discouraged by their losses, they gave up their proposed incursion into Natal. It was generally recognised that Lt. Chard's skilful and gallant defence at Rorke's Drift saved the Colony of Natal from a frightful disaster.

Captain B. L. Sclater, R.E., in Nyasaland and East Africa.

In Nyasaland, or British Central Africa, we find the work of an R.E. who played a great part in opening up Africa.

Captain Sclater, R.E., made the first road from the coast into and through Nyasaland.

I have not found any particulars of his work in Nyasaland, except that it was road work, but, when he had finished there, he moved on to East Africa to make an unmetalled road for ox transport from Mombasa to Lake Victoria Nyanza.

On that work he was assisted by Lt. G. E. Smith, R.E., better known as "Uganda Smith." He is now Brig.-General Smith, retired, and he sent me a most interesting pamphlet which he published, describing the work which Sclater and he did in the construction of this road.

The first 180 miles of road from the Coast had been made by the Imperial British East Africa Coy., and Sclater's job was to carry it 400 miles further through only partially explored country to Victoria Nyanza.

Five R.E. N.C.O.'s assisted them: Lce.-Corp. Smith, Corp. Ellis, 2nd Corp. Clarke, Lce-Corp. Simmonds, and Lce.-Corp. Brodie.

Exploring and reconnoitring for the road through all kinds of country, plains, hills, ravines, forest, bush, etc., laying out the road, and constructing bridges, were the engineering problems that confronted them, but problems of a different nature also had to be dealt with.

In 1895, British East Africa had few white people in it. Negotiations with native tribes for the supply of labour, the organising of caravans of transport to obtain food, and to supply it to the working parties; the arrangements for payment. These questions all required considerable organising and administrative talents. Captain Sclater possessed unusual powers of influencing natives and gaining their friendship and co-operation.

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Several times they had to interrupt their work to march to the assistance of some of the small garrisons that were dotted about the country to keep order.

In those days there was no coinage current in East Africa. Payment was arranged by barter, and currency varied in every district. It might be brass wire, iron wire, American and Bombay sheeting, beads, old uniforms, cartridge cases, knives, looking-glasses, etc., etc.

Lt. Smith writes in his pamphlet :

> " I found it necessary to enquire into the price of food and animals which had been bought in my absence. It was a difficult job. My headman, following their usual custom, used to allude to every item as being worth so many sheep, and each sheep as being worth so many rings of brass wire, but I soon found that, though a sheep might be worth ' x ' rings of brass wire, and an ox worth ' y ' sheep, the ox was not worth ' xy ' rings of brass wire. I had to invent a fabulous animal, which I called an ' exchange sheep,' to get over this difficulty, the ' exchange sheep ' being worth about half what the real animal cost."

It is quite evident that Lt. Smith was not followed into the heart of Africa by a Local Auditor.

Their adventures with wild animals, and the excellent big game shooting, made a pleasant variant to the normal work. There used to be several trophies of Uganda Smith's rifle in the R.E. mess.

The unmetalled road, 400 miles in length, was completed in a little over 18 months for an expenditure of £17,000, which is £42 10s. 0d. per mile, a fabulously cheap performance. I think Smith must have done some skilful work with the currency, and inflated his "exchange sheep " a bit.

The road being finished, the Government then asked Sclater to create, and organise, a Government ox-transport service along the road from the coast to the lake.

Sclater started to do this, but, unfortunately, his energetic work over a period of years in tropical Africa had undermined his health, and he died at Mombasa.

THE UGANDA RAILWAY.

Roads alone will not develop a new country. Railways also are necessary.

In 1891-92, Captain (now Major General Sir) J. R. L. Macdonald, R.E., surveyed for a railway from Mombasa to Uganda.

The party consisted of Macdonald, Captain J. W. Pringle (who is now Sir John Pringle, Chief Inspector of Railways to the Ministry of Transport), Lt. P. G. Twining (afterwards Director of Fortifications and Works), and Lt. H. H. Austin (now Brig. General), all of whom had gained their experience on railway surveys in India, on the Kabul River, and in the Zhob Valley.

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They divided into two survey parties, which in nine months marched 4,280 miles, surveyed 2,724 miles, and located a railway route 657 miles in length.

When the railway was subsequently built Macdonald's location was adhered to, except in the last section approaching lake Victoria Nyanza, where an alternative route was followed, but now, after a lapse of thirty years, they find that Macdonald was right, and a line is being built on his original location.

Expeditions in East Africa.

In 1897, Macdonald was given command of an important expedition, which set out from Mombasa to forestall Marchand at Fashoda.

The French had started Marchand from West Africa to get a footing on the Upper Nile, hoping thereby to neutralise the effect of Lord Kitchener's approaching re-conquest of the Sudan. Macdonald's Expedition was a counter to Marchand's.

When, however, he was passing Uganda, he was recalled to that Colony to put down a very serious mutiny of native troops. This duty, perforce, occupied so much time that his expedition to Fashoda had to be abandoned as too late.

Macdonald, Austin, Gwynn, Maud, L. C. Jackson, led numerous survey expeditions, exploring and mapping the country between East Africa and the Sudan and Abyssinia, delimiting the frontiers between the two last named.

One of Austin's expeditions suffered terrible hardships, and he had great difficulty in extricating a small remnant of his followers from the attacks of hostile natives.

Other R.E. in East Africa.

One of the most successful Governors of British East Africa was Sir Percy Girouard, who moved to East Africa after governing Nigeria.

At the present day the Corps is represented in East Africa by Brig.-Gen. G. D. Rhodes, who is Chief Engineer of the Kenya Uganda Railways, engaged upon a programme of new railway construction costing four to five millions.

I have already mentioned that Col. G. A. P. Maxwell is General Manager of Railways in Tanganyika.

Abyssinia.

Abyssinia lies next to East Africa. The only European Force that ever fought its way into the heart of Abyssinia was commanded by an R.E., Field Marshal Lord Napier of Magdala, who captured Magdala in 1868.

R.E. Field-Marshals.

Talking of Field-Marshals reminds me that in my service I have seen four R.E.'s who have attained that rank—Lord Napier, Sir

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Lintorn Simmons, Lord Kitchener and Lord Nicholson, so that I think we may say that the Corps has provided its quota of great leaders to the army.

SOMALILAND.

In Somaliland, Col. H. G. C. Swayne, R.E., was the pioneer of big game shooting, and the recognised authority on sport in that country.

There have been several expeditions in Somaliland in which the Corps has played its part, but we must pass on to the Sudan and Egypt.

THE SUDAN AND EGYPT.

GORDON AND KITCHENER.

In these countries, the first R.E. names that will occur to everyone are Gordon and Kitchener.

Their deeds are well known to you all. How Gordon was for many years Governor-General of the Sudan on behalf of the Khedive of Egypt. How, after he had left the Sudan, a revolt against Egyptian rule broke out under the Mahdi. The British Government, who had by then assumed responsibility for Egypt, did not consider that Egypt had at that time the resources in men and money to reconquer the Sudan. They therefore sent out Gordon to evacuate the Egyptian garrisons. How he was besieged at Khartoum, and killed there when the Mahdi captured the place after a prolonged siege, which was maintained entirely by Gordon's personality. Lord Wolseley's expedition had been despatched too late in 1884 to rescue the beleagured garrison.

It was at this time that Major Kitchener first came into public notice. Before Lord Wolseley's expedition had been sanctioned by the Home Government, and while it was still very uncertain whether Gladstone would be persuaded to despatch such an expedition, Major Kitchener went as an Intelligence Officer to Dongola, hundreds of miles beyond any support, to keep an eye on the Emir of that province, and hold him to the Egyptian cause. If the Home Government had not sanctioned Lord Wolseley's expedition there is no doubt that Kitchener would never have returned from Dongola. However, Lord Wolseley, as we all know, was allowed to proceed with the attempt to relieve Gordon at Khartoum. Later on, Kitchener commanded an Egyptian cavalry regiment, an Egyptian infantry brigade, was Governor of the Red Sea Littoral, reorganised the Egyptian Police, and was appointed Sirdar of the Egyptian Army.

SIR GERALD GRAHAM AT SUAKIM.

While Lord Wolseley's Expedition was making its way up the Nile, a Force was sent to Suakim to occupy the Dervishes in that area, and to prevent them moving to oppose Wolseley. The Suakim Force was commanded by an R.E., Lieut. General Sir Gerald

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Graham, V.C. At El Teb and Tamai he gave the Dervishes two of the hardest blows they ever received.

Other R.E.'s with Lord Wolseley in Egypt and the Sudan.

Many other Royal Engineers distinguished themselves in Egypt and the Sudan at this period. It is only possible to mention a few.

Col. C. M. Watson was on the Intelligence Staff when Lord Wolseley conquered Egypt in 1882, and played a great part in the capture of Cairo by Sir Drury Lowe's cavalry.

Colonel (now General Sir Richard) Harrison, was A.Q.M.G. of L. of C. Staff in the 1882 Egyptian Campaign.

Colonel Sir Charles Wilson was Lord Wolseley's Chief Intelligence Officer when he was trying to relieve Gordon at Khartoum, and took over command of Sir Herbert Stewart's Column when that officer died at Metemmeh from wounds. Sir Charles Wilson proceeded in a steamer right up to Khartoum, and brought back the news of its capture.

General Sir Herbert Chermside was Governor of the Red Sea Littoral.

The Reconquest of the Sudan.

In March, 1896, Sir Herbert Kitchener, as Sirdar of the Egyptian Army, received instructions from the Government to start upon his famous reconquest of the Sudan, which culminated 2½ years later in the battle of Khartoum.

Many Royal Engineers took part in these operations. Captain Gorringe (now Lt. General) was A.Q.M.G. of the Egyptian Army, and responsible for the organisation of supplies and transport on which the success of the Expedition so much depended.

Major Kincaid was on the staff of a division. Major Lawson (now Lt. Gen. Sir H. Lawson) commanded Arab levies.

Railway Work in Sudan Campaign, 1896-99.

A great feature of the Campaign was the railway work carried out by Lt. Girouard with R.E. officers, assisted by N.C.O's and men of the 8th and 10th Railway Companies, R.E.

Five-hundred-and-eighty-five miles of railway were built in 2¼ years—200 miles from Wady Halfa to Kerma in the Dongola Province, and then 385 miles from Wady Halfa via Berber to Abuhamed.

You will notice how often in this lecture I have had occasion to refer to the work of N.C.O.'s and men of the 8th and 10th Railway Coys., R.E. It really is remarkable how the men of these two small companies have left their mark all over Africa in the construction of important railways, which are serving that continent.

From Wady Halfa to Abuhamed the railway crossed 235 miles of waterless desert. A former Khedive of Egypt had tried to find

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water by sinking wells in many parts of this desert, but had always failed. It was not anticipated that we should have any better success, but two R.E. subalterns (one of whom is now Major-General Stevenson), after reconnaissance, found a place about ninety miles from Wady Halfa where they thought it worth while to sink a well, and, to everyone's surprise and satisfaction, a splendid unfailing water supply was found which has filled up every locomotive from that day to this.

Other attempts to find water were made elsewhere along this desert railway route to Abuhamed, but so far without success. The finding of this water facilitated the building of the railway across 235 miles of desert, although the problem of watering construction parties and locomotives still remained a formidable one.

The Corps lost two very promising subalterns in the construction of these desert railways—Lieuts. R. Polwhele and E. H. S. Cator.

Telegraph Work in Sudan Campaign.

Lt. Manifold (now Major-General Sir G. Bowman-Manifold) was responsible for the telegraph work throughout the campaign.

Administration and Development of the Sudan.

I cannot attempt to tell the story of the reconquest of the Sudan, or of all the fighting in Egypt and the Sudan from the time Lord Wolseley landed there up to the present day.

The British Government became responsible for the administration and development of these countries, and the R.E. took up a big share of the work.

Lord Kitchener was, of course, the first Governor-General of the reconquered Sudan.

Col. Gorringe was Governor of the Blue Nile Province. I have already referred to R.E. work on survey of the Sudan and Egypt.

Captain J. S. Liddell was head of the Sudan Telegraph Dept. When he took over the telegraphs of Egypt he handed over the Sudan telegraphs to Lt. E. V. Turner, who is now Colonel on the General Staff for Signals at the War Office. Turner was succeeded by J. P. Moir, who is now Chief Engineer Anti-Aircraft Defences of England.

Captain M. R. Kennedy became Director of Public Works in the Sudan. This officer first came into notice by designing a scaffold which would hang six brigands simultaneously in Crete, at the time when an International Force was operating there under the command of Major General Sir Herbert Chermside.

The designing of such a scaffold seems hardly sufficient qualification for appointment as Director of Public Works in the Sudan, but he selection was justified, as Kennedy carried out some very important works and buildings in that country.

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Port Sudan.

Probably his most important work was the construction of a fine new harbour at Port Sudan on the Red Sea. As its name implies, it is *the* port of the Sudan. His Resident Engineer for this great work was Lt. Kelly, R.E., who was unfortunately killed in France in the Great War. Some idea of the size and nature of this harbour work can be given by the following few particulars :

There are five berths, each 410 feet long, which vessels run alongside.

One berth is equipped with four large electric coal transporters, delivering either direct into truck, or to a coal-distributing bridge in rear.

For general cargo, four 3-ton, and 7 ton, electric jib cranes are fitted, which can be used for cargo on any of the five berths.

A floating crane deals with loads up to 60 tons.

On the quays are four Customs' sheds.

In 1924, 699 vessels entered the port, whose total tonnage was 2½ millions, and they landed and shipped 481,000 tons of cargo.

The largest vessel that has entered the harbour had a tonnage of 27,000.

The Sudan and Egyptian Railways.

Major Girouard handed over the Sudan railways to Major Macaulay (now Sir George Macaulay) when he proceeded to take up the very important post of President of the Egyptian Railway and Harbour Board. When he left that appointment to proceed to the other parts of Africa in which we have traced his activities, Major Macaulay succeeded him in Egypt, after handing over the Sudan Railways to Captain E. C. Midwinter, R.E., under whom the system was greatly extended and improved. In this he was assisted by several R.E. Officers, among whom I would mention Newcombe, Sowerby, a very able R.E. Officer who died in Palestine during the Great War, and Russell, who recently handed over command of the Training Battalion at Chatham, in order to take up the appointment of Military Attaché in Chile.

Midwinter is now Controller of Sudan Railways in the London Office of the Sudan Government.

Blakeney, now Brigadier-General, and Clifford Hall, now Colonel, moved from the Sudan to work in the management and traffic departments respectively of the Egyptian Railways. Blakeney in due course became General Manager, and Hall, Traffic Manager. The latter is now a Director of the Anglo Egyptian Bank.

Military Works of Egyptian Army.

The military works of the Egyptian Army were in the hands of the Royal Engineers, first under Col. L. B. Friend, who was afterwards

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Director of Fortifications and Works at the War Office. Major P. G. Grant, now G.O.C., Chatham, and Inspector of R.E., was also head of the Military Works of the Egyptian Army.

CONCLUSION.

We have now travelled over most of Africa.

I have omitted many names of R.E., and much useful work done by them in Africa. Notably I have omitted their good work in the Great War in Africa, because it is impossible to give an exhaustive account within the limits of this lecture.

To recapitulate, I have shown you how Royal Engineers have played a prominent part in every campaign, and in every expedition in Africa.

How they have played a great part in opening up and developing that great continent by surveying it, by constructing harbours, railways, roads, telegraphs, buildings, water supplies, and numerous other works, and last, but not least, by administering and governing some of its territories.

The Great War showed what excellent training for Engineers in war this work in Africa had given to the men who did it.

But the work they have done has only served to open up this vast continent, and to start its development. The African Continent awaits the Royal Engineer of the new generation to carry that development several stages further.

That brings me back to the point with which I started this lecture, which was to show you the great *variety* of the opportunities, and of the work, which come to the Royal Engineers, and I have been dealing only with Africa, which is only a portion of the British Empire.

By all means get into the Staff College if you can, but you can't all get into the Staff College, even under the latest Army Orders. Only 17 out of the 111 officers I have named in this lecture passed through the Staff College.

But, whether you go to the Staff College, or whether you don't, we may reasonably expect that the work which lies before you in the great British Empire will offer you as great a variety, and as many opportunities, as your predecessors enjoyed, and that you will thus be able to train yourselves by interesting and constructive work in the British Empire for your duties as Royal Engineers in War.

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CO-OPERATION BETWEEN R.E. AND R.A.F. IN AND BEYOND INDIA.

By MAJOR A. V. GOMPERTZ, M.C., R.E.

SCOPE.

This article is offered as a corollary, not a disputant, to Brevet-Major Dewing's article in the June, 1926, issue. With the exception of the two premises given below, and of one point of detail, the former article may be applied equally to India. The scope of these notes is intended to cover the work which any R.E. officer must be prepared to take charge of in peace and war, in India, and in a war conducted from India, particularly beyond the North-West Frontier. Where detail is descended to, it is local detail only.

TWO PREMISES.

The first and most important of these is the diametric difference which obtains between the R.A.F. works and building services, at home and in India respectively. At home, as Major Dewing points out, this service is a civilian one, possibly enlistable on the outbreak of war. In India, all works for the R.A.F. beyond the province of their own technical sections for aeroplanes and motor transport, are executed through the single agency of the R.E., in the Military Engineering Service. This covers anything, literally, from patch repairs to a landing ground, up to the construction of an entire new R.A.F. Cantonment such as we have at Drigh Road.

Whether or not the home R.A.F. works organization is enlisted on the outbreak of war, it is, and foreseeably will long remain, out of the question to consider a similar system for India. There exists in peace time no civil R.A.F. works staff ; 1914-8 taught us fully the dangers of avoidable improvisation in all quarters ; and there is, moreover, in India no such civil reserve of competent engineers as is to be found in European countries. In a large or a long war based upon India the R.E. cadre would certainly be expanded by civil engineers with temporary commissions ; but it may be taken as virtually certain that the R.A.F. works service will remain in war, as it is in peace, the business of the parent Corps in the first place.

In the writer's opinion the arrangement is a very fortunate one, at any rate for the Corps. One of its direct effects is that, in peace time, an appreciable number of R.E. officers of all ranks are in a position to obtain a close insight into the working and requirements of the Royal Air Force, to a degree which would be very difficult to obtain in Great Britain ; and they are thus able to store up personal experience which should prove of great value to both arms in war.

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The second premise, in respect of conditions in and beyond India, is the greater quantity of R.A.F. work which must fall to the R.E. compared with that which they would be likely to encounter in an European war. The writer begs to support most strongly Major Dewing's statement that " It is all very well to call the preparation of aerodromes the ' duty ' of the R.A.F.; it certainly sounds like being the work of the Army." In India there is practically no other side to the question at all. In India, as at home, the personnel of the Royal Air Force has at its disposal very few men-hours indeed in proportion to those required for purely flying duties and those duties directly ancillary to them. In war this situation is likely to become much more marked still : neither in peace nor war can the taxpayer afford to maintain trained British airmen to do work which can be performed effectively and far more cheaply by local labour. Even landing grounds, which are very minor things when compared to aerodromes, need annually in India a good deal more work upon them than could ever be found by the R.A.F. personnel without disproportionate detriment to the flying service, and some of them in constant use are located hundreds of miles from the nearest R.A.F. unit. Standing regulations for landing grounds do, indeed, lay down that the R.A.F. shall only call upon the R.E. for such work as they are unable to perform themselves ; but in practice, climate, wind, weather and soil, to say nothing of finance, ensure that the bulk of the work falls on the Corps.

The Sapper east of Suez must thus be prepared, whether he is with a Divisional unit or on the Works Directorate, to do any or all classes of work for the R.A.F.

Bearing this in mind, it is fortunate that a large proportion of the Works and the Field cadre of the Corps in India is located broadly where the entire local complement of the R.A.F. works, i.e., on and north-west of a line joining Karachi and Delhi. In consequence, the prospects open to the R.E. officer of getting experience of R.A.F. works at some time or other during his Indian service are quite good.

It may be of use to look briefly into the main classes of work which would probably fall to the R.E. on behalf of the Air arm in a campaign within the theatres visualized, confining the list to items in which the limits of the Indian etablishment of the R.A.F. would render it necessary for practically the whole of the work to be done by the Corps, with only a close and continual liaison with the R.A.F. to see that their requirements were accurately met.

Taking existing circumstances as they are, in the shape of squadrons, stations and the like : probably the first need in the tactical series would be for more landing grounds, both advanced ones for co-operation with the headquarters of Military formations, and emergency grounds for the safe landing of damaged machines and

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the execution of light repairs. As work upon landing grounds in India has special characteristics, which are in detail rather the province of the Sapper than of the Airman, a separate note on these is inserted later.

With the landing grounds, there comes at once the question of approaches to them from the existing ground communications, by road, or rail, or both, according to availability. A landing ground with no good communication to it by ground is less good than the proverbial sick headache. The road approach, moreover, should not only be good enough to stand ordinary medium loads, such as might be necessary in ordinary circumstances, but it should stand up at need to the heaviest R.A.F. vehicles, if time, labour and material permit. R.A.F. engines do not grow on trees, and the accident of a machine, with a write-off undercarriage and an undamaged engine, could make the easy access of a crane-lorry a very valuable asset when the engine supply base is hundreds of miles away.

Again, at the outset of operations, local bomb-proof, or, at the least, splinter-proof, protection for considerable stores of aerial bombs and fireworks could easily become a requirement of first importance at places far in advance of the usual arsenals and bomb-stores. So long as they are far enough back to be tactically safe—and in this both ground and air tactics are determining factors—the further forward that fighters, co-operation machines and bombers can leave the ground, the better.

So much for actual tactical considerations. Thereafter there come the questions of works which are second nature to the Sapper on the Indian establishment, to wit, hutting and/or housing, water supply, conservancy, workshops, electric light and power required in any excess over what the small R.A.F. portable plants can supply, assistance in the erection of hangars or their entire erection if they are big semi-permanent or permanent affairs, and so on. None of these items need any special note to the Sapper, save that of water supply, in view of the particular local conditions. On and beyond the frontier, water is an eternal question; and although it is so greatly important that both the strategical and tactical conduct of campaigns have to fall in closely with it, there are times when the Sapper will have to make special efforts to enable the field for strategy and tactics to be enlarged, just as was done upon the dry upland reaches north of the Somme in 1916, and in the arid country east of Port Said. As a general rule, the broad process will be the development of existing resources to the utmost, the use of a good deal of power plant of many designs is fairly certain to arise; but at times the active co-operation of civilian expert geologists and tube-well specialists may be a matter of high import. The Sapper likely to be employed upon works in the field on or beyond

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the frontier, for the Army and R.A.F. alike, can do no better than keep his water-supply knowledge thorough and up-to-date.

After this brief survey of possible works for the R.A.F., there remains to insert only a brief note on liaison. In practice, this can hardly be too close. There is never any question of the Sappers being under the R.A.F. for their technical work, although with big R.A.F. headquarters in the field there may be R.E. officers permanently attached, just as they are in certain positions in India in peace-time. It may be remarked that liaison does not lie only in office visits at stated hours; one of its strongest factors for efficiency is close personal acquaintance. In peace, in our own district, the R.A.F. were good enough to allow junior R.E. officers in direct charge of R.A.F. work to live in the R.A.F. Mess, if there was one in the station; the practice proved a great help, and should be equally good in war for all ranks employed on R.A.F. work alone.

LANDING GROUNDS.

Some special notes need to be made about landing grounds, since not only is this class of work one of the items whereat Sappers and Pilots come closest into co-operation, but out-station grounds are apt in practice to be almost entirely in R.E. charge, subject only to inspection by pilots.

Here it is necessary to differ in one detail from Major Dewing, who states that such grounds must be as broad as they are long and need only be 400 yards square for occasional use. The size varies with the main classes of machines likely to use them. The R.A.F. will always supply details; but in India a 400-yard square would not ordinarily be considered large enough for anything but a Bristol Fighter. For D.H.9-A's, the other normal type in India, it is best to allow not less than a 500-yard run. There are, of course, pilots who will put a machine down almost on the legendary "tennis court;" but the man to be legislated for is the ordinary pilot in trying weather, and it needs to be remembered that a machine can be put down without trouble on bits of ground where it may be very difficult to get it off again. The square shape is not vital, though of course desirable. The essential is to give a run of sufficient length in the direction of the prevailing wind or winds, of a breadth of 200 yards and upwards. In the writer's own district, landing grounds were of many shapes, from a 500 x 500 "L" shape of 300 yards width to the Aerodrome landing grounds of 1000 yards square. The R.A.F. fix what they will accept, and thereafter accurate ferrotype maps, continually up-to-date, should be distributed to those concerned, even in the case of temporary manœuvres landing grounds.

It has already been pointed out that in India a considerable charge of landing grounds often falls to the R.E.: the subject, therefore, needs careful study. Bad work at any time may cost a valuable

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machine, to say nothing of two very valuable lives, perhaps, as well. This is where the Sapper comes in. The Pilot knows what he wants; but it is not within his work to know exactly how to obtain and maintain it on all the different classes of ground in India. That is the Engineer's job, and it is thus of the first importance for the Sapper to know where a machine can land and where it cannot, and how to set matters right.

The easy grass of Britain is, in India, rather the exception than the rule; there are grounds of sand, of earth, of "put" (best defined as sun-baked mud), of powdery shale, and of any or all of these mixed with rock. Nor is there any golden rule for all their maintenance year in and year out. Quoting at random, the "put" ground at Sibi is a death-trap of deep heavy mud after a lot of rain: when dried out, its surface is a shiny billiard-board for the wheels, whilst it still breaks up comfortably well under the tail-skid so as to stop the machine quickly. From year's end to year's end it needs virtually no care, save for its barring from use during and after rain, and for the filling in of rat-burrows, which make wheel-traps as the rain washes them bigger. At Reti, one "hop" from Sibi for a 2-tanker Bristol, is a sand ground which can behave very well in ordinary weather, although a couple of hours of sandstorm can raise mounds costing at least an undercarriage. At Quetta is a big ground of sandy earth on a very slight slope; in 1924 a single hot-weather downpour tore nullas in it big enough to wreck the largest machine in the world.

It may be judged, then, that for the care or selection of landing grounds alone, quite apart from the much wider questions of reconnaissance and intelligence dealt with by Major Dewing, it is very desirable that the Sapper in charge of R.A.F. works should know the Pilot's point of view. This he can only get by being thoroughly at home in the back seat of a Service machine.

If he is to do his work with 100% efficiency, he must be fully at home in the air; he must know when a bad landing (seen or felt) is or is not the fault of the ground; he must know gliding angles by heart, and he must be able to pass fairly accurately any landing ground for any normal type of machine. The R.A.F. officer is naturally the final and only judge in these matters; but, as already indicated, he has neither time nor opportunity to find out exactly what in India is necessary to make a landing ground out of a particular wilderness. That is the Sapper's job; and the more he knows of the Pilot's outlook, the better will his work be for the side. To attain this, he must—"must" is the word—fly.

Suggested Training.

The following remarks constitute suggestions as to how the R.E. officer can set about proper liaison; they apply equally to a know-

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ledge of landing grounds as to the wider duties of reconnaissance, etc.

Opportunity in India is distinctly good for those officers who are in direct charge of R.A.F. work. There are, of course, the classes in Army Co-operation held by the A.C. Squadrons each training season, but the vacancies are few, and those falling to the Corps, of course, much fewer still. Nevertheless the Sapper on R.A.F. work can make a good deal of his own running without them.

Not only is he in continually close contact with the R.A.F. over his work, but the Army Co-operation Squadrons are frequently able to give lifts to Army passengers; and with other squadrons and Depots the necessary authorization to fly is easily forthcoming, so long as flying is restricted to duty trips in actual connection with work. The Royal Air Force is helpfulness itself, so long as there is a back seat vacant or a machine and Pilot free, and the job is one of genuine work.

It may, perhaps, be of use to describe the system laid down by the writer, as C.R.E. of two successive Districts, for the development of proper liaison. The object was, in the presence of the opportunities already mentioned, and in the natural absence of any cut-and-dried regulations governing a fluctuating case, to get the best out of those opportunities by systematic means, instead of leaving their exploitation to individual choice and chance. The affair being thus unofficial, no more than verbal and informal advice and approval was asked for from R.A.F. officers; but it can certainly be claimed that the system produced good results.

To begin with, every R.E. officer in actual charge of R.A.F. work had to fly. It was no difficulty to get them to do so: the difficulty lay in dealing patiently with their day and night requests for chances to fly more and more. Needless to say, such flying as was done was subject entirely to the orders and convenience of the R.A.F., who were at the same time more than kind in meeting requests. Next, officers were permitted an absolute maximum of six hours' air time in which to get "air sense" before being sent up on jobs of work. During that time, which spread naturally over some weeks or more, they had to pick up the more ordinary gambits and gadgets of the backseater's existence, such as :—

(i). Feeling absolutely at home in the air.
(ii.) Familiarity with air harness, and with working in it.
(iii). Helping to start up an engine—a vital necessity when halting at out-station landing grounds in India where there is often no one but a Pathan *chowkidar*.
(iv.) Filling up, use of the chocks, turning a plane round by hand, guiding a taxi-er by a wing tip, etc.
(v). Dropping message bags occasionally, and firing Very lights as wind indicators for the pilot.

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(vi). Reading and recording any of many dials for the Pilot if desired by him, and, of course, understanding them.

(vii). Simple cross-country navigation; this was second nature to the Sapper, of course.

(viii). No stunting, but keeping one's target in sight, as well as direction-sense in the more ordinary moves, such as steep sideslip descents and stalling turns.

(ix). Practising observation all the time.

They had, furthermore, to note take-offs and landings very carefully, and to watch other machines getting off and on, so as to study the behaviour of the ground.

It will be seen that the aim was not only to produce officers with air sense and with an insight into the pilot's point of view, but also to give the pilots reason to feel that they had behind them not merely so much deadweight, but a man who could do something towards earning his passage at halts and in ordinary slight trouble.

At the end of six air-hours, it was reckoned that R.E. officers should be quite fitted to take their places in back seats for all the ordinary work likely to come their way, to the natural exclusion of purely R.A.F. duties such as photography, wireless, and expert aerial gunnery. Thereafter they were not sent up save on definite duty, by the C.R.E's orders or the R.A.F's request, for specific tasks, such as :—

(*a*). Periodical inspection of outstation landing grounds. This was the commonest trip. Apart from the advantage of inspection by landing, a comparatively short ferry trip would save the Sapper one or even more whole working days in view of the slow and restricted train services of India. A longish trip, with intermediate stops, would save anything from days to weeks.

(*b*). R.E. Reconnaissances, with or without amateur photography. (A V.P.Kodak will give surprising air photos.) A lot of useful work was done in this way, in tackling big storm-drainage and river-training problems, as a supplement to ground work.

(*c*). Special trips. These might include the selection (with or without landing) of new landing grounds, such as are temporarily required for manœuvres, the inspection by night of obstruction lights provided by the R.E., and occasionally quick ferry trips by the kindness of the R.A.F., for urgently arising and distant military duty; and odd special jobs generally.

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It may be added that when an R.E. officer had, as far as his own share went, passed any landing ground as fit for use, efforts were made to arrange that he should, if possible, be in the back seat of the first machine to use it. There was anything but reluctance to this.

So much for the system; it is claimed that it worked well. Its direct result was that Sappers got gradually to see all their work much more from both sides' point of view. "The basis of co-operation is an intelligent understanding of the other man's job," and the very close liaison which grew from making officers not only fly but learn to help work their passage, was of the greatest benefit to them in their own work and training, and so, one hopes, to the Royal Air Force as well.

It is this form of co-operation which the writer desires to put forward strongly. At home, of course, conditions are different; but in India, where the Sapper replaces entirely, even in peace, the Works and Buildings staff of the R.A.F., he has unrivalled opportunities of seeing the working of the Force at close quarters. It is thus urged that he should take them and use them to the utmost that his own work and the R.A.F's convenience permit.

For the efficient commanders and staffs of to-morrow, air sense will be not less than an essential; for the Sapper on R.A.F. work it can fairly be called so already, for the Sapper on his own work the future holds much of necessary R.E. aerial reconnaissance. The time to begin working towards air sense and a long start in facility for co-operation is now.

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ARTHUR FFOLLIOTT GARRETT PRIZE ESSAY, 1926.

By Captain G. F. Heaney, R.E.

Subject Selected :—" Survey on Active Service."

The Essay is to take the form of a Report and recommendations on the following points which arise in connection with the particular case outlined in paragraph 2 :—

(*a*) As Director of Surveys, appreciate the situation from the survey point of view and state the policy and programme that you would adopt. Is it likely that more than one scale will be necessary ? What projection would you employ and what steps would be taken to begin survey operations ?

(*b*) Do you consider the resources of the Field Survey Company adequate in personnel to undertake the programme you have outlined ? If not, what additional personnel do you consider necessary ? What reply would you make to the offer of the Colonial Survey given in paragraph 7 ? The issue of maps and photographs is to be done by you down to Brigades and Divisional Troops. What arrangements would you make ?

2 The force consists of 2 Divisions and 1 Cavalry Brigade with the normal proportion of non-divisional and L. of C. Units. These include 1 Field Survey Company *plus* Photographic Section and 1 Map Depot. All are at small war establishment. A third Division with additional non-divisional troops is to be sent out later if required.

3. The Base will be a small seaport town of about 10,000 inhabitants in a somewhat backward country. The objective will be 100 miles inland. Landing and advance will be opposed. The attitude of the civil population is uncertain. Operations are not expected to last more than six months, but are expected to include one decisive battle. The enemy is in possession of 3 Batteries of Modern Field Artillery and is plentifully supplied with modern machine guns and rifles.

4. Local topography may be divided broadly into the following zones :—

(i) The coastal part, average width about 20 miles, is heavily timbered (virgin forest) and includes large areas of mangrove swamp. Visibility poor.

(ii) The second zone, 5 miles in width, is composed of small foothills rising to the terrace edge of zone 3. The conditions are those of open English park land. Visibility fair.

(iii) Zone 3. Starting at a height of 3,000 feet the country rises progressively to 5,000 feet at the objective. There is little or no timber and the visibility is known to be good.

5. There is no railway and there would be considerable difficulty in constructing one across Zones 1 and 2. Roads are not numerous and

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are all unmetalled, except the main highway to the objective. Country transport includes both carts and pack transport.

6. The Base selected and its immediate environments are fairly well mapped at the scale of 2-inches to the mile. A very bad ¼-inch map, almost blank for Zone 3, contains the only detailed topographical information.

7. The Survey Department of a neighbouring Colony has offered the services of a small volunteer geographical unit raised from its staff. The offer has been provisionally accepted and further details as to what is required have been promised.

Notes on Stores and Equipment.—1. The topographical section, armed with revolvers and issued with pantaloons, may be mounted if necessary.

2. The stores and equipment for trigonometrical and topographical surveying may be taken as adequate (for the numbers) for any method given in the *Text Book of Topographical Surveying.*

3. The printing machinery includes 1 double-demy flatbed machine (500 copies per hour in one colour) and two proving presses. The camera takes double demy negatives and both helios and vandykes can be made.

THE first duty of a Director of Surveys on being appointed to a force operating in a little known country is to obtain all possible information about the country from every source.

The information given in setting the problem is very scanty, so in Section i this is supplemented by information, which it is only reasonable to suppose would be in the possession of the Director of Surveys before the beginning of the campaign.

This essay is divided into three sections, as follows :—

Section i. A brief description of the country and of events leading up to the war, and an appreciation of the survey problems involved.

Section ii. Personnel, organisation and programme of work.

Section iii. Map production and distribution.

SECTION 1.

Topoland is a small independent state, roughly rectangular in shape, covering an area of about two degrees of latitude by four degrees of longitude. On the west it is bounded by the sea and on the south and east by the large British possession, Kohara ; while to the north lie the possessions of another European power. The boundary between Topoland and Kohara runs approximately along the crest of a ridge of mountains, and transport difficulties render an invasion from this direction impracticable.

The capital town is in the middle of the state, and is connected with the only port on the coast by a metalled road, which, after crossing the forest-clad coastal zone, winds its way over the edge of the interior tableland, and then follows the course of an open valley towards the capital.

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As far as is known, water and supplies are fairly plentiful, and, should the inhabitants prove friendly, small survey detachments should have no difficulty in living on the country.

A short time previously the king of Topoland was driven into exile, and sought British aid. The anti-British policy of his successor at length compelled us to take action, and it is with the object of restoring the former ruler to his throne that the present expedition is being undertaken. It is anticipated that, once the capital has been occupied, this object will be accomplished without any difficulty, and that a prolonged occupation of the country will be unnecessary.

The Kohara Survey Department has only recently been formed, and a system of triangulation has not yet been extended to the northern frontier. It is hoped that after the conclusion of peace it will be possible to connect up any triangulation carried out in Topoland during the course of the campaign, with that of Kohara on the south and east.

The War Office have already arranged for a sufficient supply of the 2″ map of the seaport to be issued to all troops likely to require it; the $\frac{1}{4}$″ map of the country contains so little information that it is not considered worth while to make a general issue of it, but a limited number of copies has been issued down to battalion headquarters, for use till more detailed maps are available.

Appreciation. In the event of the landing being strongly resisted, it may be some days before units destined for field headquarters or the Base can land, so arrangements will have to be made on board ship for any air survey work likely to be necessary during this period.

The only practicable route for advance through the coastal forest zone is along the main road, and the G.O.C. will probably content himself, at the outset, with occupying a corridor through it sufficiently wide to insure his lines of communication against molestation from a flank. The area to be mapped immediately will, therefore, probably not extend for more than 15 miles on either side of the road.

The duties of a Director of Surveys with an advancing army in an unmapped country are:—

1. To ensure that the army shall be adequately supplied with maps, however rough, of the area of operations, no matter how rapid the advance may be.
2. To undertake the systematic survey of as much of the invaded country as circumstances will permit, and to prepare and publish maps of this area.

To give effect to this policy the survey organisation under his control must be divided broadly into two sections, one of which will work in as close touch as possible with the General Staff and the Royal Artillery, and will meet all urgent calls for maps and trigonometrical data, as they may arise; and the other of which will undertake the systematic survey of the country behind the lines, making use

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of and supplementing the work of the forward section. This rear section will, as far as possible, carry out work according to a fixed programme, which will be independent of unimportant variations in the military situation.

The general requirements in maps in a campaign of this description are likely to be :—

(*a*) 1″ maps for ordinary tactical purposes.

(*b*) 3″ maps for a deliberate attack on a prepared position. Should a period of trench warfare set in, then 6″, or even larger, scale maps of particular areas may be required. Air photos will be largely used in compiling maps of this class.

(*c*) Maps on a scale of 1/250,000 for administrative purposes, situation maps, etc.

(*d*) Large scale maps of limited areas at the Base or on the lines of communication for laying out camps, etc. As it is not anticipated that the campaign will last for more than six months, there is likely to be only a very small demand for these.

The problem that now arises is, whether we can use methods of air survey to map the country behind the enemy's lines, and if so, what ground survey will be required to provide control for it, and afterwards to supplement and check it.

Air surveys of this kind, combined with a system of rapid map production, would clearly be of the greatest value, as it is obviously desirable that the army should be provided with maps of the country over which it is going to operate.

Behind our own lines, in open hilly country such as that of zones (ii) and (iii), air survey on a 1″ scale in its present state of development cannot compete either in accuracy or rapidity with plane-table survey.

In the coastal zone, however, the conditions are very different. To survey this area by any ground method would be extremely slow and difficult ; to carry a system of triangulation across it, without special towers from which to observe, would be practically impossible, and air survey seems to provide the only solution of the problem of mapping it with any rapidity. The country closely resembles that of the Irrawaddi delta recently surveyed so successfully in this way. There, control points were fixed by running systems of triangulation or traverse lines along the coast and up the main creeks ; but here, if the coastal forest zone is to be mapped before its occupation, some other method of control must be used. Two alternatives present themselves. The first is the method used in Palestine during the late war ; control strips of photographs forming triangles were taken from a constant height all over the area to be surveyed : these strips were considered to be all of the

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same scale, which was ascertained, and were rotated in azimuth till the common points at their ends coincided. The remainder of the area was then photographed with overlapping parallel strips of photographs which were adjusted to fit these control strips. The second alternative is to use the existing $\frac{1}{4}$" map to provide control. This map gives a certain amount of detail in the coastal zone, which will probably provide enough points identifiable on the photographs, to enable a controlled mosaic to be constructed. Later, after the occupation of the area, should a more accurate map be required, additional points could easily be provided by ground survey and the mosaic readjusted accordingly. This alternative seems to promise to be more satisfactory than the former one and will therefore be tried. With this end in view, the air force will be asked to take control strips at right angles to the main direction of the photography, at intervals of about $7\frac{1}{2}$ miles and along the line of prominent features, such as the main road or large creeks. Later, if necessary, traverse lines will be run along these features, and additional fixed points marked on the photographs of the control strips, thus enabling the work to be re adjusted.

In giving instructions to the air force the following points should be noted :

Scale of photography to be not less than 1/20,000 (or there may be difficulty in interpreting detail).

A lens of short focal length may be used.

A 30% overlap between photographs is required in each direction.

The greatest care is to be taken to maintain a constant height during the entire photography.

On receipt of the photographs a rectified mosaic will be constructed by the method described by Prof. Melville Jones in his book, "Air Survey by Rapid Methods," and detail will be transferred from it by pentagraph to a map on the required scale.

Using the figures given in this book, the area of about 600 square miles should be photographed in about eighteen hours flying. This photography should be completed, if possible, before the landing takes place, to enable a map to be issued at the earliest opportunity.

The problem of air surveying the country behind the enemy's lines in zones (ii) and (iii), will not be so simple, as there will be distortion to contend with in most photographs, due to differences in the height of the ground, and the scale in any strip will vary for the same reason. It is not, however, impossible of solution. In 1922, very similar country on the North West Frontier of India, inaccessible to ground surveyors, was mapped on a 1" scale from air photographs ; later, when the area had been occupied, the work was checked on the ground, and was found to be quite accurate enough for ordinary military requirements, though useless as an artillery map, owing to the impossibility of contouring it accurately.

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Prominent points had been fixed throughout the area, from a distance, and were identified and marked on the photographs, which were pasted together in strips. The essence of the method of compilation was then to draw in lines of latitude and longitude at one-minute intervals, by interpolating between these fixed points. The quadrilaterals so formed, which varied slightly in shape and size, were then reduced by pentagraph to the correct scale and transferred to the map, being adjusted during this latter process to fit correctly. Contours were put in approximately by examining overlapping pairs of photographs through a stereoscope and interpolating between known heights. This method is clearly not an exact one, and requires considerable skill on the part of the compiler, but has been found to give satisfactory results in practice.

The United States War Department, in their manual of *Training Regulations for Aerial Photographic Mapping*, describe a method of building up a system of control from overlapping photographs, which they call the " Radial Line Method," which will, they claim, enable them to map hilly country accurately as far as fifty miles in advance of ground control. Although possessing theoretical faults, this method, combined with that first mentioned, should be of considerable value in the present instance.

To fix the positions of points behind the enemy's lines should not present any particular difficulties, as the country slopes up towards the objective and the more prominent hills will be visible from a considerable distance.

The methods of plotting from individual photographs used in France during the late war will not, as a rule, be possible, as there is no accurate existing map from which to obtain fixed points.

Although no Director of Surveys would be justified in neglecting the possibilities of air survey, yet as its success is so largely dependent on the weather and the skill of the pilots available, and is, therefore, not assured, he will have at the same time to make arrangements for carrying forward plane-table surveys wherever possible, should air survey prove a failure.

Even should it be successful, it will not be possible to dispense entirely with plane-table surveys, as the air survey maps will require contouring, and detail will have to be checked and amplified on the ground.

During the advance through zones (ii) and (iii) the following will be the main duties of the advanced part of the survey organization :

1. To carry forward a system of triangulation, and to fix the position of sufficient points ahead and on either flank for plane-table surveyors to work from, for the compilation of air survey maps, and to enable the artillery survey section to fix the position of bearing pickets.
2. To compute the spherical and rectangular co-ordinates

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of these points. The spherical co-ordinates will be issued to surveyors and the rectangular co-ordinates to the General Staff, who pass them on to the artillery and any other units requiring them.

3. To compile maps from air photographs.
4. To carry forward plane-table surveys. Should an air survey of the area have already been completed, the plane-tabler will work on a blue print of this, checking and amplifying detail where necessary, and inserting contours.

To enable the triangulation system to keep pace with the rate of advance, should the latter be rapid, two observers will be employed, one working on each flank. Each will be allotted one mounted trigonometrical surveyor, who will go ahead and erect marks at the stations which will be subsequently occupied. The closest liaison will be necessary between the two observers, and each day, before commencing observations, they will visit some prominent point together and decide the positions of their next stations, and which points they will intersect. On return to camp each evening all work will, as far as possible, be computed up to date.

The four topographical surveyors of the Field Survey Company will be sufficient to carry out all plane-table surveys likely to be required in the forward area, along the main line of advance, but will clearly be unable to survey the whole country up to the line of the objective, during the six months the campaign is expected to last.

To enable as much as possible to be surveyed in the time available, the services of the small geographical unit offered by the Kohara Survey Department will be required. This unit should have trigonometrical surveyors, computers, plane-table surveyors, draughtsmen, etc., in the correct proportions to render it self-contained and allow it to be independent of military assistance.

Should the General Staff decide that maps of the remainder of the coastal zone, in addition to that portion to be mapped at the outset of the campaign, are necessary, this remaining portion will also be air surveyed and the work of compilation will be entrusted to the colonial geographical unit. It is therefore desirable that some of the members of this unit should have had previous experience of work of this kind.

Projection.—The properties desirable in a projection for military maps are :

1. That sheets should fit together at the edges so as to form a continuous map.
2. That it should be suitable for the superimposition of a rectangular grid, and that the computations for the conversion of spherical to rectangular terms should be simple.
3. That it should be such that one system of rectangular co-

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ordinates should cover the whole area of operations without the errors towards the extremities exceeding 1/1500, or that considered allowable for military requirements.

The other features affecting the choice of a projection are :

(*a*) The area and greatest length of the proposed survey, and the direction of the length.

(*b*) Whether there is any possibility of the extension of the survey, and in which direction this extension is likely to be.

(*c*) The existence or otherwise of an adjoining survey with which it is desirable to conform.

We will now consider how these factors affect the problem we are considering.

The greatest length of Topoland lies in an east and west direction, and there is the possibility of an extension of the survey to the west and south at some future date, to join up with those of Kohara. The Conical Orthomorphic Projection on two standard parallels fills requirements 1 and 2 above. On this projection a grid may be superimposed and extended for an indefinite distance east and west without the introduction of serious errors, over a belt of about six degrees of latitude. If we so arrange the projection that the southern border of Topoland is about midway between the two selected standard parallels, the belt of six degrees will include the whole of Topoland and as much of Kohara as is ever likely to be required on the same grid system. This projection, therefore, admirably fills all our requirements and will be adopted.

SECTION II.

PERSONNEL, ORGANISATION AND PROGRAMME OF WORK.

The Field Survey Company will be divided into two groups as under :

The Reproduction Half Company, situated at the Base.

The Forward Half Company, situated at the discretion of the Director of Surveys, in the most convenient place for keeping in touch with the General Staff and with the forward work, generally at Field Headquarters.

The Reproduction Half Company will consist of :—

1 Subaltern from Coy. H.Q.
1 Clerk do.
Photographic Section
Power Section
Litho Section
Drawing Section } Less personnel and transport attached to the Forward Half Company.

The Forward Half Company will consist of :—

Company Headquarters (less 1 subaltern and 1 clerk at the base).

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Topographical Section

1 Helio Worker
1 Machine Minder
1 Prover
2 Lithographic draughtsmen
} Attached from the Litho Section.

2 Draughtsmen (attached from the drawing section).

Equipment and transport

1 Proving press

Vandyke Equipment

1 Petrol-electric lorry (from Litho Section).

1 Three-ton lorry (from M.T. Company).

Forward survey work will be organised as follows :—

2 *Triangulation Squads*, each consisting of,
1 Subaltern
1 Trigonometrical Surveyor (to go ahead and erect signals)
Men for carrying instruments and erecting beacons.

Air Survey Squad. (In abeyance unless air photographs are available.)
1 Subaltern (from triangulation squad.)
2 Draughtsmen.

The senior subaltern will be in charge of air survey work, and when required for this his place as an observer will be taken by one of the two spare trigonometrical surveyors.

Computations :
1 Computer (from topo. section).
1 Computer (from company H.Q.)
2 Observers.

4 *Plane-table Survey Squads* (two working on each flank) of :
1 Topographical Surveyor
Men for carrying instruments

These plane-table survey squads will be mounted should the O.C. survey company consider it advisable.

Spare :
2 Trigonometrical Surveyors.

These men will be kept in reserve to replace casualties, to help with computations, or for any other work that may be required.

Reply to the Kohara Survey Department.

A reply will be sent to the Kohara Survey Department, confirming the provisional acceptance of the offer of a small geographical unit, and continuing as follows :—

" The General Staff have decided that it is desirable to map as much as possible of Topoland on the 1" scale during the time available. The personnel of the survey company allotted to the force is only sufficient for carrying out surveys along the line of advance, and when the latter has penetrated some distance inland, there will be considerable areas behind the lines which

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the survey company will be unable to touch. It is to carry out the survey of these areas that the geographical unit from your department will be required.

" This unit should be self-contained, with its own complement of computers, etc., and be under the command of a gazetted officer, who will deal direct with the Director of Surveys, and will be exempted, as far as possible, from other military interference in his work.

" As it will be impossible for this officer to commence work till the expedition has crossed the coastal forest belt and penetrated into the hills of the interior, you will be notified by wire, the approximate date he should report for instructions to the Director of Surveys at Field Headquarters. He should be accompanied by an advance party of two triangulators, who will commence work as soon as possible ; and he will then make all arrangements for the remainder of his unit, who will be required to commence work about three weeks later.

" The work required of the unit will be,

" Triangulation for a 1" survey.

" Plane-table surveys on a 1" scale.

" Fair drawing of the sheets surveyed.

" In addition to the above, should the General Staff decide that the whole of the coastal area is to be mapped, traverse lines will have to be run through it and a map produced from air photographs. A portion of this coastal zone astride the main road will be mapped from air photographs, by the survey company at the beginning of the campaign, and this may prove sufficient for military requirements.

" As it will be quite impossible for a small unit to map the whole country up to the line of the objective during the few months likely to be available, the services of as large a unit as you can raise will be very gladly accepted. It is anticipated that there will be no difficulty in obtaining all the unskilled labour required, locally."

PROGRAMME OF WORK.

Before and during landing operations.

1. Photography by air force of a belt of country thirty miles wide astride the main road, through the coastal zone.
2. Construction of a map from these photographs.

After the landing has been consolidated and an advance made from the base.

1. Observations for latitude, longitude and azimuth on which to base traverse work.
2. Commencement of traverses along the coast and up the lines of the " control strips " to provide additional control for the air survey of the coastal zone.

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3. Establishment of a Reproduction Half Company at the base.
4. Drawing and reproduction of a preliminary map of the coastal zone, from air photographs.

When a footing has been established in zone (ii).

1. Observations for latitude, longitude and azimuth, and measurement of a base and base extension scheme.
2. Commencement of a system of triangulation to follow the line of advance.
3. Photography by the air force of areas behind the enemy's lines, and compilations of maps from these photographs.
4. Commencement of 1" plane-table surveys along the line of march.
5. Drawing, printing and issue of field maps as required.

After the advance has been continued into zone (iii).

1. Continuation of forward surveys.
2. Commencement of survey of the back areas by the colonial survey unit.
3. Air survey of the remainder of the coastal zone, if required by the General Staff.
4. Fair drawing and reproduction of map sheets surveyed by the colonial survey unit.

Note on equipment.

It is not anticipated that the photographic rectification of individual photographs will be either practicable or necessary, and so no photographic rectifying apparatus will be required. It may, however, be necessaary to make simple enlargements or reductions of strips of photographs. For instance, the need for this would arise should all the strips of photographs of the coastal zone be not taken from the same height. To make these enlargements, an ordinary dry plate camera of about half-plate size is required, and a simple enlarging lantern. These should be obtained at the outset of the campaign and installed at the Base.

Section III.

Map Production and Distribution.

In any system of map production on service, time is the all-important factor, and will very largely determine the methods used.

In the campaign we are considering, generally speaking, three classes of maps will be required,

Field maps.

Regular editions of 1" and smaller scale maps.

Maps required for special purposes, such as roads, water supply, traffic circuits, etc.

Field Maps will be prepared from forward surveys or air photographs, and are those which are required for operations actually in progress, or about to be undertaken. They will as a rule be drawn on tracing cloth, for reproduction by the Vandyke process in

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two colours—brown for contours, and black for the remaining detail.

Maps can be printed on a handpress at the rate of fifty copies per hour in one colour, or twenty copies per hour in two colours. Whether it will be quicker to send to the Base and have the map printed on a machine press, or to handprint it at field headquarters, will depend on the distance to the Base and the number of copies of the map required. Generally speaking, however, up to five hundred copies of a map in one colour, or two hundred copies in two colours, will be more rapidly printed on a handpress at headquarters, while larger numbers will be more rapidly printed by sending to the Base.

In order to have the latest material always immediately available at survey company headquarters, surveyors working in the forward area will, every two days, send in tracings of their work. From these a map will be drawn and kept up to date, either on tracing cloth for reproduction by the Vandyke process, or on zinc for immediate printing. Direct drawing on to zinc has obvious advantages, and will be carried out whenever possible.

Regular editions of 1" maps will be published in sheets covering fifteen minutes of latitude by twenty minutes of longitude. These will be a very convenient size to handle, and will also be very suitable for printing on the double-demy printing machine at our disposal. Maps on a scale of 1/250000 will be compiled from and cover the same area as four one-inch sheets.

These regular editions will be printed in six colours, unless otherwise ordered by the Staff, and will be fair drawn on a scale once-and-a-half times that of publication, and reproduced by the photographic process.

Maps required for special purposes will be printed as a rule in grey, and the special information will be surprinted in colours.

Distribution.—No establishment is laid down for a map depot, but the following is considered suitable for a depot at field headquarters:

1 sergeant in charge, 1 storekeeper, 2 despatch riders (mounted), 1 driver, Transport, 1 G.S. wagon and 2 horses.

Should the country permit, the G.S. wagon will be replaced by a light motor van, and the horses by motor cycles and side cars.

This map depot will distribute maps to all units in the field down to brigades and divisional troops. It will be under the orders of the O.C. Survey company.

The duties of the N.C.O. in charge of a map depot will be:

To distribute maps on the scale ordered by the General Staff.

To exchange all worn-out maps for new ones, and to keep a stock in reserve for this purpose.

The procedure for distributing photographs will be the same as for maps, but a reserve stock will not as a rule be kept. The prints will be supplied by the air force direct to the map depot, who will merely serve as distributing agents.

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SHELL FIRE VERSUS PERMANENT FORTIFICATION. LIÈGE AND NAMUR, 1914.

By CAPTAIN G. E. GRIMSDALE, *p.s.c.*, R.E.

THE *R.E. Journal* for December, 1926, contains a very interesting article by Lieutenant Harrison, R.E., on Verdun. The object of the present article is to offer a few comments about the conclusions reached by Lieutenant Harrison.

These comments are based on a visit to certain of the forts round Liège and Namur, which the present writer had the good fortune to make in the spring of 1926. The visits were made under the personal guidance of a Belgian Staff Officer, serving in the Historical Section of the Belgian General Staff. In addition, in a number of cases it was possible to discuss the experiences of men who had actually been present during the German attacks. These men are now serving as caretakers and so on in the forts. First-hand information was therefore available as to questions of fact.

The object of a fortress is to deny to the enemy the use of a certain area. Owing to the great cost, it has hitherto been impossible to construct a series of fortresses so close together as to protect the whole of an extended frontier area. The construction of fortresses has, therefore, been confined to localities of great strategic importance. As roads, rivers, and railways are essential to the movements of armies, fortresses have usually been constructed so as to protect important centres of communication. It is thus that Liège and Namur, which are situated at important centres of road, river, and railway communications, have been the sites of fortresses from the earliest times.

Lieutenant Harrison has pointed out how the increasing range of artillery necessitated the construction of a girdle of forts round the important strategic centre, at such a distance as to protect that centre from hostile artillery fire. The extent of this girdle ultimately became so great that it was found necessary to provide a mobile garrison to defend the large intervals between the forts.

This stage had been reached in the latter part of the 19th century, at which period the fortresses of Liège and Namur were rebuilt. Each of these strategic centres was protected by a girdle of some 12 forts. The forts lay at a distance from each other of 1½ to 3 miles, but, owing to difficulties of ground, were unable to afford each other

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mutual support. Each fort was sited on a prominent feature, from which the visibility in all directions varied from 800 yards to several miles. The garrison of a fort varied between 300 and 400 men, of whom the majority were gunners, the remainder being infantrymen. The intervals between the forts were defended by fortress troops of an inferior category. Each fort consisted of an inner keep where the main armament was mounted, a deep ditch and an outer rampart, the whole being surrounded by a belt of wire. Certain forts had also a secondary armament of light guns placed at the angles for special flanking fire. The guns were of various calibres and were mounted in revolving steel cupolas. The fort itself was built of concrete and was proof against 21-cm. shell, as also were the cupolas. Within the keep were the headquarter office of the commander, accommodation for the garrison during battle, ammunition chambers and a well. Most of the accommodation and ammunition storerooms were below ground level, ventilation being practically non-existent.

It is believed that no reinforced concrete was employed in the construction of any of the forts. Certainly, in many cases, the concrete used was very inferior, the contractors having been allowed apparently to use large boulders and brick rubbish as aggregate. Cases were noticed where a coating of cement plaster had been used as camouflage to bad work. It appeared from careful enquiries that the Belgian High Command were aware in 1914 that 30-cm. shells were likely to be used against these forts, but lack of money prevented any strengthening of the concrete or steel cupolas. The facts were therefore concealed from the garrisons, who were encouraged to, and did in fact, believe that they could remain under cover in the fort with safety from any German bombardment. The 42-cm. howitzers, which the Germans actually used, were, of course, as much a surprise to the Belgians as to the other allies.

The fortresses of Liège and Namur undoubtedly caused a certain delay to the German advance in 1914, but the rapidity with which the forts were reduced by mobile heavy artillery showed clearly that that type of fortress was a failure. The reasons for this failure may be summarised as follows :—

(a) The Germans used heavy howitzers up to 42-cm. calibre, whereas the forts were only proof against 21-cm. Thus the gun had developed while the fortress had remained the same.

(b) As the forts had been sited on the top of commanding features, observation was carried out from the gun positions. Generally, the method of obtaining observation was to fit at the highest point of the fort a kind of steel umbrella, capable of being raised vertically a few

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inches, so as to give all-round vision to a man standing beneath. As soon as the fort came under concentrated fire, however, observation became difficult, while in nearly every case the first direct hit on the central keep of the fort deposited such a weight of débris on top of the "umbrella" as to prevent it from being raised. If it had already been raised, apart from the dust, splinters, etc., the lumps of concrete thrown up all round made observation impossible. The result was that observation was then confined to what could be seen by looking down the barrels of the various guns. In certain cases also, buildings and trees had been allowed to grow up within a few yards of the forts, thus effectually obstructing the view over large areas of country. Thus the lack of observation at the critical moment prevented the main armament of the forts from carrying out its rôle of counter-battery work.

(c) Direct hits on the fort by even light artillery caused the inferior concrete to chip, and the broken fragments jammed the cupolas and prevented them from turning. In this way many of the guns were able to fire in one direction only.

(d) Communications were totally inadequate. The forts were connected to each other and to the commander of the fortress by air lines, which in many cases were cut in the early stages of the battle. There could thus be no effective control by the commander of the fortress.

(e) Owing to these fortresses being intended for all-round defence, the forts were designed and sited primarily to withstand attack from outside the perimeter of the fortress. The most serious defect in design was the entrance to the main ammunition store. This was in the central keep directly opposite the entrance to the fort. The latter in every case naturally lay at the back, on the side nearest the town, i.e., on the farthest side from which attack was expected. The actual passage and stairs were designed to lead straight down from the ground level to the store room, there being no corners or traverse to give protection.

Thus at Liège, Fort Loncin, situated west of the town, was attacked from the east, after the town had fallen, though it had been designed primarily to meet attack from the west. One of the first 42-cm. shells directed on the fort went straight down the passage stairway leading to the

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main ammunition store, the entrance to which was on the east side of the fort. This shell exploded the chief magazine, blowing up the whole fort with some 500 to 600 defenders, including the gallant commander of the fortress.

(f) The design of the forts was defective in many other ways. For example, the electric light failed under bombardment, ventilation was insufficient, particularly when the guns were firing; while the latrine accommodation was outside the keep and inaccessible to the garrison during bombardment.

The latter was apparently the immediate cause of the final surrender of at least one fort. The writer will long remember a survivor's vivid description of the stench in a large, unventilated, candle-lit, underground chamber, in which several hundred men had been rigidly confined for some days by a continuous bombardment.

(g) The intervals between the forts were held by isolated and lightly entrenched and wired infantry posts, but the wiring was not continuous. As a result, the enemy were able to pass at night between the posts.

(h) A further effect of these fortresses being designed for all-round defence was that the 20,000 elderly troops who formed the garrisons were distributed over a perimeter of some 30 miles. Thus the fortress system broke the principle of economy of force.

Again, at Liège, the fortress acted as a magnet for the 3rd Division of the Field Army, which remained within the enceinte, thus the fortress system led to the breaking of *another* principle of war—that of mobility.

(i) The principle of concentration of force was applied to the gun instead of to the shell. The guns were massed in forts and had to distribute their fire over the enemy batteries which were widely separated, while the enemy, from his scattered gun positions, could concentrate his fire upon the forts.

Some of the reasons why the frontier fortresses of Belgium failed in 1914 have now been examined, and it remains to consider in what way it is possible to replace such fortresses in the future. After studying the question on the ground, the writer has come to the following conclusions:—

(1) The conclusion of Lieutenant Harrison that "a line of isolated fortresses . . . must be replaced by a system of fortified areas . . . " is correct. These areas must form a continuous zone for the defence of the frontier.

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(2) This zone should be organised in depth for the co-ordinated action of all arms, and should form part of the national defensive system.
(3) The basis for the organisation of this zone should be the artillery and machine guns, and the artillery should be mobile.
(4) The infantry trench and wire systems should be continuous.
(5) The most important work in connection with the preparation of this defensive zone will be the construction of artillery observation posts and machine gun emplacements, the selection and trigonometrical survey of battery positions, and the laying of telephone communications at such a depth below ground as to render them proof against artillery fire.

It is really with the second of the three categories, into which Lieutenant Harrison divides the defensive organization of this zone, that the present writer cannot altogether agree. It is clear that in the interests of secrecy, and also on the score of expense, it is not desirable that the whole of the work in this defensive zone should be carried out in peace time. But, on the outbreak of war, time for work will be short, and, further, it must be remembered that any newly constructed works will be clearly revealed by air photographs. If, also, the works constructed in peace are small, numerous, and widely distributed, the knowledge of their exact position by the enemy will be of little importance; for the enemy will be unable to concentrate upon all these numerous works the great number of shells which the last war showed to be necessary for their destruction.

In fact, the construction during peace time of "elaborate defensive works" should be avoided for the future and not encouraged. Instead, the following rough outline of what should be done is suggested as more likely to bring about the desired object, and as being more suited to the needs of a hard-pressed treasury.

(1) A detailed reconnaissance of the defensive zone should be made and the actual sites of all headquarters, battery positions, O.P's., machine gun posts, trench systems and wire should be decided upon and committed to a secret map.
(2) A plan of defence complete in every detail must be evolved and all arrangements made for the immediate construction on the outbreak of war of those works not previously prepared in peace time. This plan must take into account the supervision of the area, to ensure that

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buildings and natural growth do not interfere with the field of fire or of view.

(3) Depots of all stores required on the outbreak of war must be prepared.

(4) The whole defensive zone must be trigonometrically surveyed and all battery positions resected.

(5) The following work should actually be carried out in peace time :—

(a) The construction of reinforced concrete artillery O.P's. and machine gun posts. These should be allowed to become overgrown with turf in such a way as to render them invisible from the air.

(b) The laying at great depth of buried telephone cables, so as to provide a complete system of communication. These cables should be laid to a large number of alternative battery positions.

(c) The construction of concrete gun platforms for heavy artillery. These platforms might be camouflaged by being constructed as floors for wooden farm outbuildings.

(d) The preparation of roads or railway lines with gun spurs, in order to permit of free movement of heavy artillery within the position. At present, railway lines are necessary for the movement of super-heavy artillery, but, in view of the fact that it is very undesirable that such lines should be constructed in peace, it is considered that experiments should be carried out to arrive at a design whereby super-heavy artillery can be moved, or even fired, on tracked carriages.

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THE EFFECT OF MECHANICALIZATION OF THE ARMY ON THE ORGANIZATION AND EMPLOYMENT OF DIVISIONAL AND CORPS ENGINEERS IN THE FIELD.

By MAJOR R. H. DEWING D.S.O., M.C., R.E.

Second Essay. Cooper's Hill Memorial 1926.

MOTTO.

"Peace, friend Sancho," answered Don Quixote: "for matters of war are, of all others, most subject to continual change."

I. THE ENGINEERS' PLACE IN MECHANICALIZATION.

ALTHOUGH " mechanicalization of the army " is an expression which has now acquired a very narrow meaning, its real meaning is a much wider one. We now generally limit it to the change which is most prominent in our own generation—the supplanting of horse-drawn transport by power-driven transport. In its broad sense it should include the adaptation to military purposes of any mechanical device which can replace or economise muscular energy.

In its broad sense, mechanicalization has been going on steadily in the armies of the world since the dawn of history. The first use of wheels, the evolution of catapults and ballistae, the invention of fire arms and the development of the modern machine gun, are some of the landmarks in a process of evolution which has been continuous since savage men first felt the need of weapons to help hands and teeth.

To-day, men still walk on their feet in our battles, and horses still strain at traces, but comparatively few of the other actions of our infantry and gunners would find their counterpart at, say, the battle of the Granicus. Yet when we turn to our sappers, we find that they have made less progress. They still heave on ropes, hoist weights and dig the earth by methods no whit in advance of those used by Alexander's engineers at the siege of Tyre.

Of course the military engineer has made use of the developments of mechanical science. Our tools, equipment, transport and methods of work prove that; but a great deal of the " donkey work " of field engineering is still done by elementary methods—unnecessarily elementary and uneconomical methods.

In the narrower sense, too, we find that sapper units have not taken the lead in mechanicalization. We know mechanical artillery,

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we know the light tank and the armoured car, which may replace cavalry, and there are tanks of various design which may oust infantry; but only now are we hearing the first rumour of a mechanicalized field company. Considering how closely akin mechanics is to engineering, it at first seems strange that sapper units have not taken the lead in replacing horse by petrol; but the reason is not far to seek.

If engineers worked for themselves alone, we might easily have had our mechanical field company by now; but the sapper's aim is to help towards the common object of the whole army by doing work which will assist the other arms. This consideration always did, and always will, govern their employment; and upon their employment, and the conditions under which they are to work, must depend their organization. As the other arms take their new shape, it becomes possible to foresee the work which will be required of the sapper. As we foresee the work, so we can reorganize our units; but our reorganization must always follow that of the infantry, cavalry and the artillery; we cannot take the lead.

In some branches of the army mechanicalization consists chiefly of the elimination of the horse. In devising our new units we must not be content with that. The horse may have to disappear, but but that is not the end. Our object is efficiency in the work required of us, and towards that mechanics offers many a help besides mechanical traction. For us at least, mechanicalization must have its widest interpretation. We must explore all the resources of mechanical science in our search for means of raising the efficiency of our work in the field.

II. Effect of Mechanicalization on Engineer Employment.

Speed.

The foremost effect of mechanicalization must be the possibility of rapid movement. As yet the gift of speed is most unevenly bestowed, for our army is to-day, and must for many years remain, in a state of transition between the horse-drawn and the petrol-driven organizations. The foot soldier still drags along at his two-and-a-half miles an hour, while tanks and dragons can do their eight. Yet the mechanical column is already familiar, though at present it labours under all the handicaps of improvisation. The day cannot be far distant when we shall have in our army an organisation by which at least a brigade group will be able to move entirely by motor transport. Beyond that, in the future, is the day when our whole army will be able to move by similar means. The gift of speed will then have become universal.

This access of speed must react on the engineers, who are responsible for the roads and bridges. No mechanicalization as yet within sight will make armies independent of roads and bridges. Even

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when the vision of fleets of tracked vehicles progressing unchecked across hedges and ditches, and swimming across rivers, is realised, those same vehicles will travel more swiftly and more economically on roads and over bridges. They will still be accompanied and supplied by less highly endowed vehicles, whose dependence on roads will be greater. Certainly in the immediate future, and probably for many years to come, it will only be possible to exercise the power of rapid movement where roads and bridges exist.

There have been armies capable of rapid movement before, but, time and again, their dependence on the speed at which their engineers could work has been proved.

Suvorof was a master of rapid movement, and it was through his ability to inspire his troops with abnormal energy and determination on the march that he won many of his victories over the French in Northern Italy in 1799. Yet the impulse of even Suvorof's will could not carry his army over rivers. On June 14th, Suvorof, at Alessandria, suddenly learnt that Macdonald was advancing from the south-east, while he had expected an advancè from the south-west. Ott, with a weak detachment, lay in front of Macdonald. Speed was everything if Suvorof was to reach Ott before he was overwhelmed; but the Bormida lay, unbridged, before him. Twenty-four hours of immobility were forced upon him while his engineers built a bridge. The delay would have spelt disaster for most commanders, and it was only one of the most magnificent marches in history, 53 miles in 36 hours, and a gallant attack by exhausted troops at the end of it, that made Suvorof's victory on the Trebia possible.

Bonaparte's operations against Beaulieu, in the same theatre three years earlier, prove that even his rapidity and skill in manœuvre could be nullified by the delays of bridging. Marching down the Po to cross and strike at Beaulieu's rear, he reached Placentia on May 7th, after covering 44 miles in 36 hours. "Had the army been equipped with a pontoon bridge, Bonaparte could have dealt Beaulieu a fatal blow; as he was compelled to rely on boats and rafts alone, the passage was slow and laborious."* The bridge was not completed till the 9th, and Beaulieu escaped.

If success or failure hung in the balance against the hours taken by bridging operations in those comparatively slow manœuvres of a century and more ago, how much more vital will every hour's delay become when forces can move at three times those speeds!

It will not be only bridging which must be done quickly; all work carried out for a mobile force must be speeded up. The first essential for the engineer units with the field formations of the future is that they should be able to work rapidly.

* "Napoleon," Vol. I., by Col. Dodge.

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Manpower.

Manpower is closely involved with mechanicalization. In time of peace the expense of building mechanical vehicles must become a serious obstacle to development, and every economy in personnel which can possibly be justified will be made, in order that more money may be available for construction. The army will be organized on a basis of the maximum of efficiency with the minimum of personnel.

In war, the importance of the man in the workshop and the necessity for conserving national manpower, will be enough to guarantee that the same policy will be followed.

This will react in two ways on the engineers. We must expect reduction rather than increase in the strength of our engineer field units, and must therefore be prepared to undertake work without any increase in the number of available sappers. Secondly, a difficulty with which we are already familiar—that of obtaining unskilled labour to enable the sappers to be confined to skilled work—will be aggravated. To-day, in case of necessity, a working party may be grudgingly spared from an infantry battalion; but squeezing water from a stone will be easy compared with obtaining a working party from a battalion of one-man tanks.

Type of work.

Besides bringing changes in the conditions of speed and labour under which the engineers are to work, mechanicalization will also entail some changes in the actual work required in the field.

Armies will depend more and more upon roads fit to carry a large volume of quick-moving mechanical transport; and construction and maintenance of roads will form an increasing proportion of the engineers' work. Loads tend to become heavier and heavier, and the demands for bridges capable of carrying the increased weights will grow accordingly.

Demolitions will lose none of their importance, but will develop into schemes of destruction on a large scale; for the more dependent our enemy is upon his roads, the more effective will become the obstacle constituted by really efficient demolitions. At the same time, except in deliberate demolitions, the sappers will find the time available for the preparation of their charges shorter than ever. Demolitions during retreat have always been difficult: they will become even more difficult when the retreat and pursuit are carried out more quickly.

Anti-tank defence.

The whole problem of obstacles in the field will be altered when we are confronted by an enemy with tanks in really large numbers. Barbed wire may then become a relic of ancient warfare, and small

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mines and other anti-tank obstacles may become necessary on a scale hitherto unknown.

The mine must become the most important anti-tank obstacle for field formations. It alone, of the obstacles yet devised, can be put in position with the speed which mobile operations will often demand. But though the mine will be the primary obstacle, it would be a mistake to ignore other obstacles, such as barriers of steel rails set in concrete, or wide deep ditches. These may sometimes have their place, even in mobile operations. We must not become so obsessed with the idea of mobility as to exclude the deliberate preparation of defences from our conception of future warfare. Field formations will often have to construct defences in one area as a preparation for mobile operations in another; and whenever these defences are likely to be attacked by enemy tanks, concrete will play a large part in their construction.

Our engineer units must be able to undertake the construction of a system of defences, including numerous concrete machine gun emplacements and anti-tank obstacles, and to complete it quickly.

III. Means of Meeting the New Conditions.

Time saving.

The ability to work rapidly is the first essential for our field units; and time can be saved, not only in the execution of a job, but also in the stages of reconnaissance and preparation, which must precede execution in almost all sapper work. These first two stages both entail movement, movement of the reconnaissance party to the site, and movement of the working party with its tools and material to the same spot. So long as any of this movement is carried out on foot, time is being wasted. The future organization of the engineer field units must therefore provide for the movement of all personnel, tools and material, by some form of rapid mechanical transport.

The stage of preparation usually entails loading and unloading material of some sort. In civil work it is often possible to save time and labour by using a light crane or a mechanical grab for loading, and by providing lorries with tip bodies for unloading. It is not easy to devise a method of mechanical loading which will be applicable to every material which the sapper may have to handle; but if we can equip our units with gear which will assist in even half the loading they have to do, we shall have saved an appreciable amount of time.

The amount of work to be done in the stage of preparation can be greatly reduced whenever it is possible to use standardized material. Improvisation always means loss of time. As far as possible R.E stores were standardized in the later years of the war. As fresh forms of engineer work develop we must be on the look-out for opportunities for taking fresh standard stores into use.

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In the stage of execution, civil practice shows us many ways of economising time and labour by mechanicalization, in the broader sense of that word. The navvy breaking up the streets of London no longer wields a pick; he uses a pneumatic hammer. Pneumatic drills are used in excavation in rock, mechanical grabs or shovels in looser soil. Mechanical power is used to drive winches, hoists, pile drivers, pumps and cranes.

Admittedly, the problem of the sapper differs in many respects from that of the civil engineer. The field company has not to be equipped for one type of work only, but must be prepared for a very wide range of jobs. It cannot be overburdened with heavy equipment, because it must maintain its mobility. Such machinery as it uses must not be delicate, or require careful handling, but must stand up to the roughest conditions without losing efficiency. The difficulties and limitations are many, yet engineer work will not attain that speed which future conditions will demand, until our units can be equipped with power which can be readily applied in a multitude of ways.

Every section must eventually have some sort of mobile power unit capable of accompanying it wherever it goes. This machine must be able to supply power for automatic tools, to pull on a rope or drive a crane, or work a hoist, just as the job in hand may demand. It must be able to tow a mechanical trench digger or push an Inglis bridge into position. It must be equally ready to drive a pump, a concrete mixer, a stone crusher or a pile driver.

The machine which will do all this has not yet been born; but the R.E. tank of 1918 was its crude and undeveloped ancestor. If there are those who believe this mechanical factotum to be beyond the limits of possibility, let them turn over the files of any modern engineering paper and see to what diverse ends, and by what various means, mechanical power is adapted even now; and then let them imagine the delight with which an ingenious minded sapper would tackle the problem of incorporating them into one machine.

The details of the factotum may be inaccurate, but the necessity for bringing mechanical power into more general use cannot be questioned.

Labour.

If mechanicalization is to entail some reduction in the numbers within the engineer units, the answer to this difficulty is again to be found in equipping the section with mechanical power. In the course of work ten or fifteen men would no longer have to be wasted pulling on a rope; the familiar "all together, heave" would disappear from the repertory of the sapper sergeant. Instead, the power unit or R.E. tank—call it what you will—would run its winding gear for a few seconds, and the thing would be done. The pathetic sight

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of two sappers slowly and laboriously working a pile driver, and dropping the monkey perhaps three times a minute, would be seen no more. Instead, the machine would do ten times as much pile driving with far less expenditure of man-power.

With these economies a slight reduction in the number of Group E sappers in a company could be survived without any serious detriment to work.

It will not be so easy to overcome the shortage of non-sapper labour. Some of the work for which working parties are now necessary might be done by mechanical means, or at least machines might be used to reduce the number of men required. Carrying parties might often be replaced by tracked vehicles able to move across country, and the number of men required for digging could be reduced by the use of mechanical trench diggers. But the unskilled party will still be necessary for many jobs.

Our present engineer organization was adopted in spite of strong arguments, put forward in favour of increasing the establishment to include Pioneers. Mechanicalization does not make these arguments any stronger, and we should be shutting our eyes to realities if we were to picture a permanent organization including additional unskilled labour. Economy will not allow it.

Our problem is to provide the labour in the cheapest manner possible.

From the engineer point of view there is no need that this labour should have other qualities than discipline and ability to work. The men need not be trained as infantry, though they must be enlisted for work under fire. They could therefore be enlisted on the outbreak of war, and yet be fit for service in a few weeks. Their cost in peace would then be limited to the cost of their mobilization stores and equipment, which would have to be held in readiness for the rapid formation of the unit.

Economy also demands that the strength of the labour units should be kept as low as possible. This can only be done if we can ensure that the labour will only be used for essential work, and will not be frittered away on the numerous desirable, but not indispensable, jobs which every subordinate commander can so easily find when labour is available. This will only be possible if the labour is under the direct control of the Chief Engineer of the Corps.

Pooling.

Mechanical transport has given us the power of pooling our resources to an extent which was quite impossible when troops or material, which were twenty miles from the battle field on the eve of battle, could hardly hope to intervene before action had been joined. Then, bridging material had to accompany the foremost units, or be wanting when the river was reached. Now, our pontoons

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can move far back in the rear, ready to be hurried forward by motor transport as soon as the need arises.

This pooling of resources, already being applied to bridging equipment, can be applied to labour, and to certain other equipment, with great advantage and economy. The advantage of the system is that units moving with the leading formations are relieved of equipment which is not continually necessary, and which, if with the units, would reduce their mobility. Every reduction of transport in the forward areas helps to simplify the very difficult traffic problem. The economy of the system follows from the centralised control which can be exercised over the pool. Bridging material can be allotted to divisions or brigades according to their requirements, instead of being available only on a fixed scale. Labour can be allotted for specific work, and can be recalled as soon as that work is done.

The efficiency of these pools depends on good liaison, good communications, and the possession of motor transport as an integral part of the pool. Given these, it is an economical system, the use of which may be extended as mechanical transport comes into more general use.

IV. Our Future Organization.

Summary of requirements.

We can now summarise the chief points which must be embodied in our future organization :—

(1). Men, tools and material must be carried in mechanical vehicles.

(2). Power must be available for the work in the field, and it must be possible to adapt it to the most various uses.

(3). As much unskilled labour as is indispensable must be provided.

(4). Units must not be unnecessarily encumbered with heavy equipment.

To these points must be added the principles that govern all R.E. organization; the limitation of the number of subordinates controlled by one commander in the field, the maintenance of tactical unity, and the inseparability of the sapper from his tools.

From these premises it should be possible to outline the future R.E. organization within the division and the corps.

There will be no violent change in our organization. Mechanicalization is affected by evolution rather than by abrupt revolution, and the engineer units of the future will grow out of the engineer units of to-day.

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In a division to-day we have divisional engineer headquarters, three field companies, and a field park company ; while the bulk of the corps engineers consists of army troops companies, E. and M. companies, and the corps pontoon bridge park. There is no reason to suppose that any of these units will disappear. Their equipment will alter, and changes may be made in their interior organization, but in name, and in the general roles they fulfil, these units will probably still be found in our mechanicalized army.

The field company.

The future field company may be slightly weaker in personnel, but we may expect the organization of headquarters and four sections, each of four subsections, to remain.

To fulfil the requirements which have been outlined, the section would consist of :—

four mechanical vehicles for personnel, each carrying one subsection.
one mechanical tool cart.
one mechanical vehicle for technical stores and baggage, to replace the two L.G.S. wagons of our present organization.
one power unit.

The power unit has been sufficiently described. The six other mechanical vehicles should all be capable of moving across country, and maintaining a speed at least equal to that of the mechanicalized units with which the field company may work. For simplicity in manufacture and maintenance, all six vehicles should have identical chassis. The bodies of the vehicles for personnel should be easy to adapt for the carriage of material, and if they can be designed to tip for unloading, so much the better.

The headquarters of the company should continue to include all the administrative vehicles—cooker, water cart, mess and medical,—but all must be able to travel at the pace of the sections, either under their own power or as trailers.

So equipped, the company would be able to move rapidly as a complete unit, to detach sub-units of varying strengths, and to carry out work quickly and efficiently. Any sapper party would also have with it invaluable transport for collecting or carrying stores or materials.

The field park company.

The field park company is already partially mechanicalized, though its personnel still marches on foot. To enable it to take its place with a mechanicalized force it must be equipped with mechanical vehicles for its men, so that it can move as a complete unit. Beyond this there need be no great change in its organization.

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Corps engineers.

The work of the corps engineers will always be more deliberate than that of divisional engineers. Their movements will be less frequent, though, working in a large area, they may move long distances at a time. To equip all corps units with mechanical transport for their personnel would mean that much of this transport might spend many idle days, and would be uneconomical. It must be possible to move a proportion of the E. and M. and A.T. companies rapidly, and as complete units; but they will seldom all have to make rapid moves simultaneously.

The first line transport of all corps engineer units must be mechanical as indeed the greater part of it is already; but for personnel it will be sufficient if the C.E. has under his own control enough mechanical vehicles to move the men of fifty per cent. of his units at a time. These vehicles would only be allotted to units when rapid moves were necessary. At other times they would be pooled under the C.E's control, and could be used for moving stores and material.

Apart from the vehicles for their personnel, the organization of the A.T. companies should be identical with that of the field companies.

The responsibilities of the E. and M. companies for second line repairs to engineer plant will be considerably increased, and this will call for some expansion of the workshop equipment of these units.

The corps pontoon bridge park, now being organised, fulfils, in theory, the conditions required in a mechanical army. It keeps the pontoons in the rear, avoiding unnecessary congestion further forward, until they are required for actual service, when it takes advantage of the powers of M.T. rapidly to move the equipment to the point where it is wanted. But our mechanical army should have improved tractors and trailers for its pontoons. They should possess silence, for secrecy, and ability to move across country, to avoid the difficulties of handling them on a narrow road approach to the bridge site.

We have seen the necessity for a corps pool of labour. Making full allowance for all that mechanicalization can do to eliminate the need for unskilled labour, a corps labour unit a thousand strong is probably the least that can meet the calls which will be made upon it. This unit should be organized in detachments of, say, two hundred, each capable of remaining detached indefinitely from its parent unit, and each equipped with motor transport for its tools and administrative necessities. The C.E. would rely on his pool of vehicles for moving the personnel.

Mechanicalization will demand the formation of one other corps unit. We have seen that the " power units " with field companies

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and A.T. companies should be capable, among other things, of pulling trench diggers and working pile drivers, compressor plant or concrete mixers. Under certain conditions these accessories will be invaluable, but often for days and weeks at a time they will not be required with the companies. If the companies were to trail these things about with them wherever they go, their own mobility would be reduced, and unnecessary transport would be adding to the congestion on forward roads. The accessories must be available when required, but must be kept out of the way at other times. It is one more case for a pool in the C.E's hands. A unit which might be the corps workshop and park, will be wanted to hold this equipment in readiness, just as the corps pontoon bridge park holds pontoons. When it is foreseen that companies will shortly be busy with concrete work in a defensive position, the concrete mixers and stone crushers would be sent forward to them. For the preparation of extensive demolitions, compressor plant and pneumatic drills would go up to save labour in digging down through metalled roadways, and in making charge chambers in masonry.

The supply of anti-tank mines.

Though not literally part of the organization of corps or divisional engineers, the system of supply of anti-tank mines will affect the work of divisional units very closely, and reference to it must therefore be made.

Under our present organization these mines would be supplied in the same way as any other R.E. stores. In mobile operations no supply of mines would be likely to be held forward of the base engineer store depot, and, when required by a division, they would have to take their chance in the competition for accommodation on the railway. Under these circumstances there can be no guarantee that they will be available promptly. If the mines are to be used at all they will be required by the thousand, not by the hundred; and they will be wanted at short notice. The efficient supply of anti-tank mines will only be ensured when they are treated like ammunition, and are supplied through the maintenance and ammunition companies R.A.S.C. This would entail a slight expansion of these companies, based on an estimate of the scale on which the mines would be required. But it would ensure that regular echelons of supply existed, both with divisions and back from divisions to the base; and it would guarantee that sappers would be able to answer the urgent calls for anti-tank defences, which will assuredly be made upon them.

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MEMORIAL TO MAJOR-GENERAL WILLIAM ROY, F.R.S

READERS of Sir Charles Close's recent articles on "The Early Years of the Ordnance Survey" will probably remember the name of Major-General Roy, who took such a prominent part in the early survey work of this country; and will be interested to know that a memorial to that distinguished officer has recently been erected.

The following brief account of Roy's survey work will explain how it led to the establishment of the Ordnance Survey, and, consequently why Royal Engineers, and particularly those engaged on survey, should feel an interest in his memory.

William Roy was born in Carluke Parish on 4th May, 1726. After the Jacobite rising of 1745, he assisted Lieut.-General Watson, Deputy Quarter-Master-General to the Duke of Cumberland, in making a map, or large military sketch, of Scotland; the first serious attempt at a continuous map of a large portion of these islands. This work was interrupted by war; but Roy always kept in view the ideal of carrying a triangulation over the country, as the basis of an accurate map. With this object he constantly noted positions suitable for trigonometrical points, and for measuring bases, and he even carried out a certain amount of triangulation privately, in the neighbourhood of London, partly for his own amusement and partly to excite interest in the subject. But, in 1783, he was called upon to supervise a geodetic operation of the first importance, namely, a triangulation for the purpose of connecting with the French geodetic work, and so determining the relative positions of the Greenwich and Paris Observatories. As the commencement of this work a base was measured, in 1784, on Hounslow Heath.

The measurement of this base was the first operation of the kind undertaken in this country, and excited great scientific and general interest. The President of the Royal Society, Sir Joseph Banks, took an active part in the measurement, and H.M. King George III paid two visits while the work was in progress.

Though the immediate object of this triangulation was that already stated, Roy always considered that the chief and ultimate object was of a "still more important nature, namely, the laying the foundation of a general survey of the British Islands."

Roy carried the triangulation which was entrusted to him to a successful conclusion, that is, to a junction with the French work across the Straits of Dover, but died soon afterwards. His project

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of carrying out an accurate triangulation of the whole country was put in hand after his death.

It is generally considered that the germ of the Ordnance Survey lay in the military map of the Highlands initiated by Watson, and carried out largely by Roy. The actual establishment of a paid survey staff, which developed into the Ordnance Survey, took place on 12th July, 1791, when, by order of the Master-General and Board of Ordnance, special allowances were paid to Major Williams and Captain Mudge, both of the Royal Artillery, and to the party of Artillery who assisted, for the survey work on which they were engaged. Williams, and after him Mudge, were the first Directors of the Ordnance Survey, but since their time all the Directors have been Royal Engineers.

The memorial to Roy takes the form of two bronze plates which have been fixed, one on each terminal of the Hounslow Heath base. These terminals consist of guns buried vertically in the ground. The N.W. terminal is in a field known as King's Arbour, four miles west of Hounslow. The S.E. terminal is in Cannon Field, Hampton Hill. The plates are identical, except that one bears the words, "N.W. Terminal," the other "S.E. Terminal."

The inscription on the S.E. plate is as follows :—

THIS TABLET WAS AFFIXED
IN 1926 TO COMMEMORATE
THE 200TH ANNIVERSARY OF
THE BIRTH OF
MAJOR-GENERAL WILLIAM ROY, F.R.S.
BORN 4th MAY, 1726 — DIED 1st JULY, 1790.
He conceived the idea of carrying out the triangulation of this country and of constructing a complete and accurate map, and thereby laid the foundation of the
ORDNANCE SURVEY
This gun marks the S.E. terminal of the base which was measured in 1784, under the supervision of General Roy, as part of the operations for determining the relative positions of the Greenwich and Paris Observatories—This measurement was rendered possible by the munificence of H.M. King George III, who inspected the work on 21st August, 1784—The base was measured again in 1791, by Captain Mudge, as the commencement of the principal triangulation of
GREAT BRITAIN.

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The above is followed by details of the length of the base.

The unveiling ceremony was carried out at the S.E. Terminal at Hampton Hill on Tuesday, 22nd February, by the Astronomer Royal, Sir Frank Dyson, F.R.S. The following were present :

Sir Francis Floud, K.C.B. (representing the Ministry of Agriculture and Fisheries), Colonel Commandant E. M. Jack, C.M.G., D.S.O., and Lieut.-Colonel G. S. C. Cooke, D.S.O. (Ordnance Survey), Colonel H. St. J. L. Winterbotham, C.M.G., D.S.O., and Captain G. T. McCaw, O.B.E. (Geographical Section, War Office), Colonel Sir Charles Close, K.B.E., F.R.S., and Mr. A. R. Hinks, C.B.E., F.R.S. (Royal Geographical Society), Major K. Mason, M.C., R.E. (Survey of India), Mr. Stephen Mitchell, *M.P.* (Lanark), Mr. A. Miller (Carluke Parish), Professor Schlesinger (Yale University), Lieut.-Colonel O'Meara, C.M.G., late R.E., the Chairman of the Board of Trustees of theHampton Parochial Charities (Freeholders of the Site), and Mr. H. T. Mason (Leaseholder of the site).

Letters of regret were received from the following, who were unable to be present : General Sir Bindon Blood, G.C.B., Colonel R. C. Hellard, C.B. (former Director-General of the Ordnance Survey), Sir George MacDonald, C.B., LL.D., &c. (biographer of Roy), and the Officer Commanding 1st Suffolk Regiment (formerly 12th Foot, which furnished a party for work on the Base).

Colonel Jack explained the circumstances which led to the erection of the memorial, the original suggestion for which came from Sir Charles Close.

Sir Frank Dyson gave a short account of General Roy's life and work, and then unveiled the memorial.

Sir Charles Close expressed the thanks of those present to Sir Frank Dyson.

The Chairman of the Trustees stated that they fully appreciated the importance of this historic occasion, and gave his assurance that they would regard it as their duty to preserve the terminal and memorial for all time.

E.M.J.

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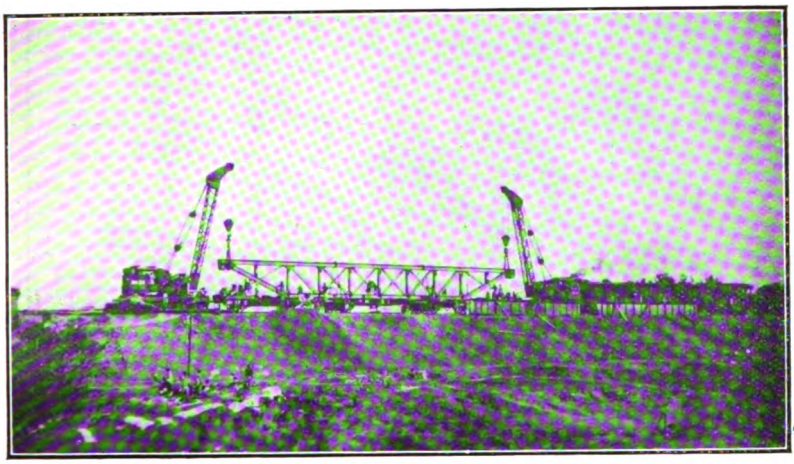

Fig. 1.

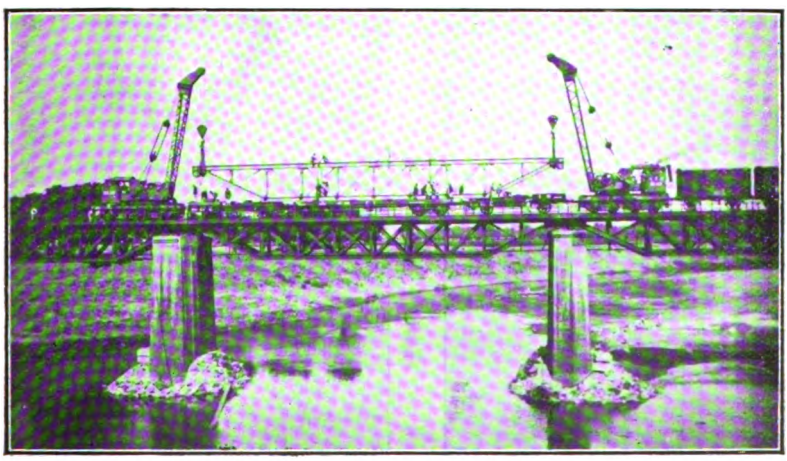

Fig. 2.

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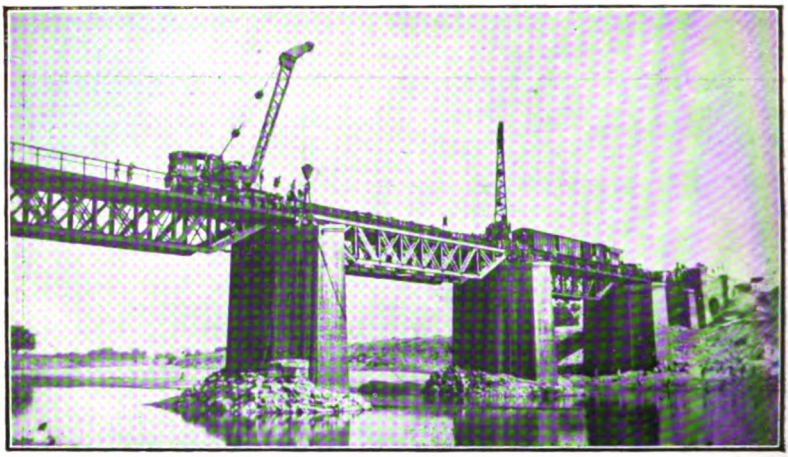

Fig. 4.

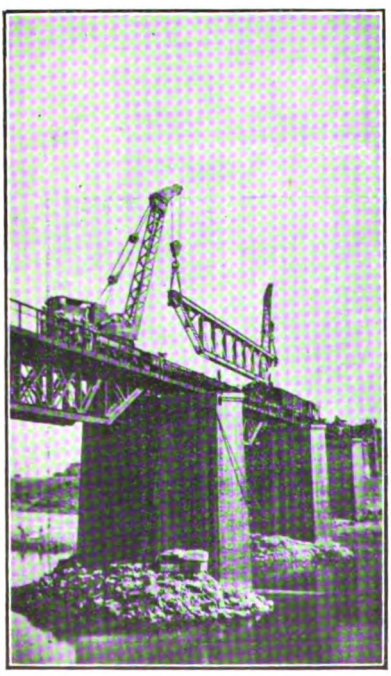

Fig. 3.

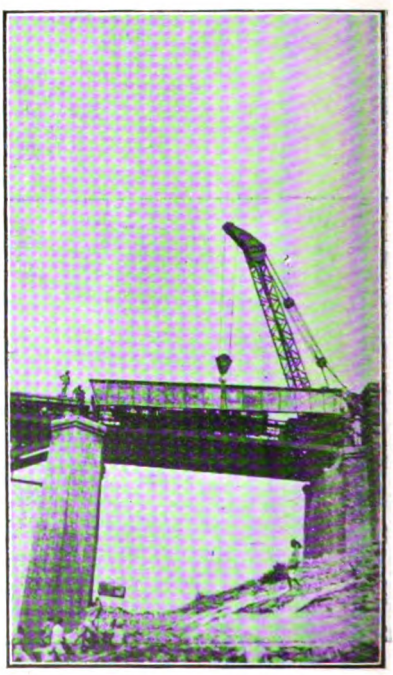

Fig. 5.

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WIDENING A RAILWAY BRIDGE.

By LIEUT. R. GARDINER, R.E.

THE following short account of a work carried out recently on the East Indian Railway may be of interest to members of the Corps.

The Grand Chord section of the E.I. Ry. has been under the process of being doubled, and amongst many other bridges was one crossing the Karamnasa River.

The bridge is a girder bridge consisting of three 100ft. spans and two 40ft. end spans. It was intended to extend the brick piers and use new girders. It was then discovered that at high flood level the water would be above the bottom boom, and it was decided to move three spans of the old bridge across the Sone River to Karamnasa and send the new girders to replace them—the Sone bridge girders being 100ft. span but shallower—rather than raise the bedstones which had already been placed. The change at Sone bridge was first carried out and then that at the Karamnasa Bridge.

As the girders were 15 feet high and weighed 32 tons each, the question of transporting them 57 miles required some thought and care.

Owing to their height it was impossible to carry the girders lying flat on their sides. The method used was as follows:

A train was made up consisting of 30 ton loco crane—flat truck—bogie platform truck—platform truck—30 ton loco crane, etc.

The girder was lifted upright on to the bogie truck and its two neighbouring trucks, and was then securely braced and strutted. 12ins. by 12ins. baulks were cut to fit under the top boom and to wedge against the edge of the truck. Baulks were also used to prevent any lateral movement of the bottom boom, and, in addition, the top boom was secured to the sides of the truck by wire ropes tightened by turnbuckles.

The train was then reassembled and the crane jibs lowered. On the journey from the Sone to Karamnasa the maximum speed allowed was 10 m.p.h., whilst through stations this was reduced to 5 m.p.h. This portion of the work was done on the day previous to that on which the actual launching took place.

The distance of the bridge from Karamnasa Station, where the train was stabled for the night, was about one mile, and the engineering department were allowed two hours in which to run out to the site, launch the girder and get clear of the main line again.

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In order to save time, before leaving the station the crane jibs were lifted and attached to the girder, and the train run out in that form (See Fig. 1.), on to the existing part of the bridge until the girder was opposite its future position. (Fig 2.)

The cranes were then propped. As the first girders erected were the nearer ones and the radius of lift quite small (20ft.), it was sufficient to prop the cranes with 12in. baulks placed on the troughing of the existing bridge.

When the further girders were erected it was necessary to block up the propping girders on the inner girders of each new span, as the radius of lift was considerably greater (25ft.)

Having then removed the struts and stays from the girder it was lifted and swung out and lowered into place. (Figs. 3 and 4.).

The three inside girders were placed first, in order to allow the propping for the outer ones, as explained above.

The 40ft. end spans were placed in position by one crane lifting each about its point of balance and lowering it into position as before. (Fig. 5.).

The points in this work may be summarised as follows :—

(1). Owing to its height, each 100ft. girder had to be transported in its most unstable position, and therefore needed great care in strutting and bracing.

(2). The train itself had to be run very slowly to prevent any undue sway being set up. (A special engine driver was chosen who could be relied upon not to cause jerks.)

(3). Owing to the limited time allowed, the crane jibs had to be raised and the tackle attached at Karamnasa station. (On the first occasion the leading jib only missed a signal by a matter of inches.)

(4). In order to be able to lift the outer girders into place the inner girders already placed had to be used to prop the cranes upon.

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IMPERIAL WIRELESS.

By COL. F. A. ILES, C.B.E., D.S.O., R. OF O.

A NECESSARY introduction to the story of the development of the wireless communications of the British Empire is a brief review of the development of wireless communication generally.

The origin of wireless is the electro-magnetic theory of light propounded by Clerk-Maxwell, including his prediction, in 1864, of ether-waves, differing from those of light and radiant heat by wave-length only. This prediction of a mathematician led physicists to experiment, until Hertz, in 1887, produced and detected the waves which carry our wireless messages, and which are called by his name.

By means of the spark-discharge from his oscillator, Hertz produced wireless waves, and he detected them at a distance of a few feet by means of his resonator.

Sir Oliver Lodge, by syntony, or tuning sending and receiving circuits alike, increased the distance to sixty yards, and, in 1894, at the British Association meeting at Oxford, using Branly's coherer and a Kelvin marine galvanometer, he showed his audience how the Morse code could be used for signalling without wires.

Marconi, by means of his magnetic detector and high aerials, made wireless a commercial proposition.

"There were strong men before Agamemnon," and the Senatore Marconi would no doubt be the first to acknowledge his indebtedness to the great men named, as also to others like Faraday, Ampère, Oersted, Hughes and Righi, who was his teacher; but for the world at large wireless, as we have it to-day, means Marconi.

In 1896, Marconi came to England. He took his inventions and ideas to Sir William Preece, the Chief Engineer of the Post Office, and sent his first wireless message in England from the G.P.O., in London, and received it on a roof in Queen Victoria Street, one hundred yards away.

Experiments were then carried out on Salisbury Plain, and the range increased to $1\frac{3}{4}$ miles with success.

In May, 1897, Marconi carried out on the Bristol Channel a test over water to a distance of $3\frac{1}{2}$ miles, and the occasion was of some importance because he was trying to do, by means of the Hertzian waves, that which had already been done with perfect success by an earlier method of signalling without wires, viz., that which works

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by induction. In 1892, Sir William Preece, having signalled by induction between two parallel telegraph wires 4½ miles apart, permanent communication was established by this means from Flatholm Fort, in the Bristol Channel, to Laverock Point, 3½ miles away.

There is a still earlier method of signalling without wires to record. In 1842, Morse had accomplished wireless signalling across the Susquehanna, and in 1859 one, James Lindsay of Dundee, having in 1845 signalled successfully across the Tay, read a paper on "Telegraphy without Wires," before the British Association, and even went so far as to make all calculations necessary for signalling between England and America. In both these instances the signalling was done by means of leakage—or earth-currents, such as we used with the Power-Buzzer in France.

In this competition on the Bristol Channel with a known and successful system, Marconi tried for three days and failed, until he thought of a possible means of improving radiation, and took his transmitter from the top of the cliff to the beach below, thus incidentally inventing the high aerial. This proved a startling success. He not only got his signals 3½ miles to Flatholm Fort, but the next day nearly nine miles across the Bristol Channel to Brean Down.

There was then no looking back: wireless henceforth meant Hertzian waves and not induction nor earth-leakage. England was the scene of the trials for the next four years, and by utilising Sir Oliver Lodge's principle of syntony, Marconi, in 1901 got a range of 200 miles over water, from the Lizard to St. Catherines, in the Isle of Wight.

In December, 1901, he went to Newfoundland, and there, by means of a kite aerial and coherer, he heard signals from his station at Poldhu. The news of this achievement caused a sudden and quite unnecessary slump in cable shares.

His experiments in Newfoundland, however, ended abruptly, for the Anglo-American Cable Company, founded in 1854 by Cyrus Field, had not only acquired the right of landing all cables in Newfoundland for fifty years, but with great forethought had worded the contract so as to exclude all other forms of signalling

Three months later the *Philadelphia*, an American liner, received messages from Poldhu to a distance of 1,500 miles, or two-thirds of the way across the Atlantic.

In July, 1902, Marconi travelled in the *Carlo Alberto*, of the Royal Italian Navy, from Dover through the Skattegat to the Gulf of Finland, keeping communication with Poldhu all the way. The *Carlo Alberto* then took him back to Italy, still in communication with Poldhu, and then across to Nova Scotia, with similar success, arriving at Sydney at the end of October. Marconi worked

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at his station at Glace Bay for seven weeks, and on December 20th, 1902, sent the first transatlantic wireless telegram to the King of Italy, and another to King Edward VII.

The next few years were occupied in fitting wireless into many liners, and into ships of the Royal Navy. The Marconi Company erected a high power station at Clifden, on the West Coast of Ireland, and started a transatlantic commercial service which went on, with interruptions, but still steadily improving, until its success raised the question of an Imperial Wireless Chain.

The idea of connecting up Great Britain and its Dominions by means of wireless appears to have originated in 1910. It was a natural outgrowth of a desire for the unity of the Empire, to which it must surely contribute, and of the success by then attained by the Marconi Company, after three years' working, with their service between Clifden, in Galway, and Glace Bay, in Nova Scotia. This service, initiated by a private company, partly for experimental purposes and to gain experience in long-distance working, and partly for commercial and press-work between Europe and the United States, became, by the accident of geography, the first wireless link between Great Britain and one of the Dominions. That all the Dominions should be linked similarly, was a suggestion put before the Committee of Imperial Defence in 1910, and referred by that body to the Imperial Conference due to take place the next year.

There was at that time no possibility of working wireless direct between England and the farthest outlying portions of the Empire, so that the Imperial Conference of 1911, in recognising the desirability of wireless communication between Great Britain and all the Dominions, could do no more than state their decision that a *chain* of Imperial wireless stations should be erected. They added that the Chain should be state-owned, and provided "without delay." Considering the sixteen years that have elapsed since the Imperial Conference made this latter recommendation, an element of pathos is not lacking.

In accordance with the main decision of the Imperial Conference, a contract for such a scheme connecting England, Egypt, East Africa, South Africa, India, Singapore and Hong-Kong (*v.* Scheme 1) was, in July, 1912, entered into by the Postmaster-General with the Marconi Company. Two important omissions will be noted. Neither Australia nor Canada appears in the list. The former, however, had promised to co-operate by erecting under her own arrangements a station at Port Darwin to work with Singapore, while the latter was looked upon as being already catered for by the existing Marconi stations.

Immediately the scheme was published controversy arose, and it was not until after a Select Committee of the House of Commons

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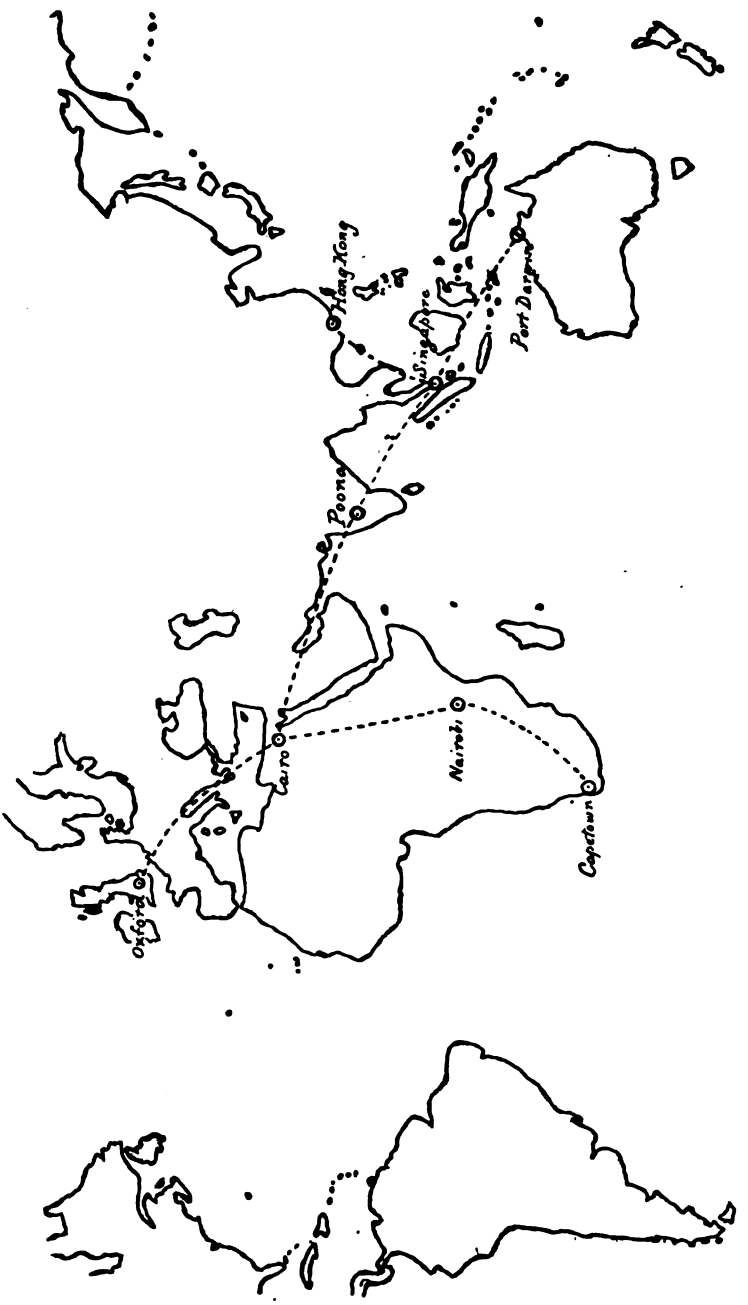
had sat on the subject, and the contract had been revised, that it was ratified by Parliament in August, 1913.



SCHEME 1.

Contract given to Marconi Coy., 1913: work stopped and contract cancelled after outbreak of war.

This brought us to within twelve months of the outbreak of war, an event which occurred when the first link of our Wireless Chain,

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consisting of the stations at Leafield, near Oxford, and at Abu Zabal, near Cairo, was incomplete, while Germany had brought its own

SCHEME 2.

Substituted for Scheme I owing to War; Carried out by Marconi's and the Admiralty.

Imperial Wireless Scheme not only to completed stations in Togoland, the Cameroons, German East Africa and German South-West

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Africa, but had installed in Germany a station of sufficiently high power to work to the farthest of them (Windhuk) direct. Germany was thus in a position to demonstrate as regards Imperial wireless communication the advantage of having schemes, carrying them out, and then making war at your own time, over general unpreparedness. That the advantage reaped was not greater was due to the possession by Great Britain of two things—the submarine cables of the world, and the Grand Fleet. In fact, the command of the sea was so securely in our hands that it led to the temporary abandonment of all idea of Imperial wireless communication, in favour of a scheme more suited to our needs. Government cancelled the contract with Marconi's, the Imperial Wireless Chain was relegated to an unknown date, and a scheme was drawn up which included sixteen widely-scattered wireless stations for working mainly to ships, and which was only incidentally used for imperial purposes (*v.* Scheme 2). The Admiralty Station at Horsea and a station, installed by the Royal Navy and utilizing the masts at Abu Zabal, brought the total number of stations to eighteen.

The Admiralty constructed three of the stations (Jamaica, Bermuda, and—by permission of Portugal—the Azores) and the Marconi Company thirteen (St. John's, Demerara, the Falkland Islands, Ascension, Bathurst, Port Nolloth, Aden, Seychelles, Mauritius, Durban, Ceylon, Singapore and Hong-Kong). In addition to the work of erecting these stations, the Marconi Company was awarded £590,000 as compensation for the cancelled contract.

By means of this scheme our larger ships were very seldom out of touch with the shore, and this with England was a point obviously of the greatest advantage. But, though the scheme thus forced upon us served its purpose, it was not truly Imperial wireless. It not only stopped the work of providing an Imperial Wireless Chain before the first link was formed, but it threw back the whole project of connecting Great Britain and the Dominions by wireless for five years.

In the case of countries other than Great Britain, point-to-point communications during the war were more important than those of ship to shore, and the United States and France were, consequently, when the war ended, each in possession of a number of high-power wireless stations working to the greatest distances, while Belgium, Holland and Italy were ahead of us in their programmes for providing such stations.

Although the submarine cables had during the war saved Great Britain in the matter of Empire communications, it was soon found when peace came that they could not cope with the rush of business and press-work following on restored foreign relations and increased commercial activity. Further, since (in spite of certain peaks of activity, such as occurred in the cable-laying world in 1870-73, and

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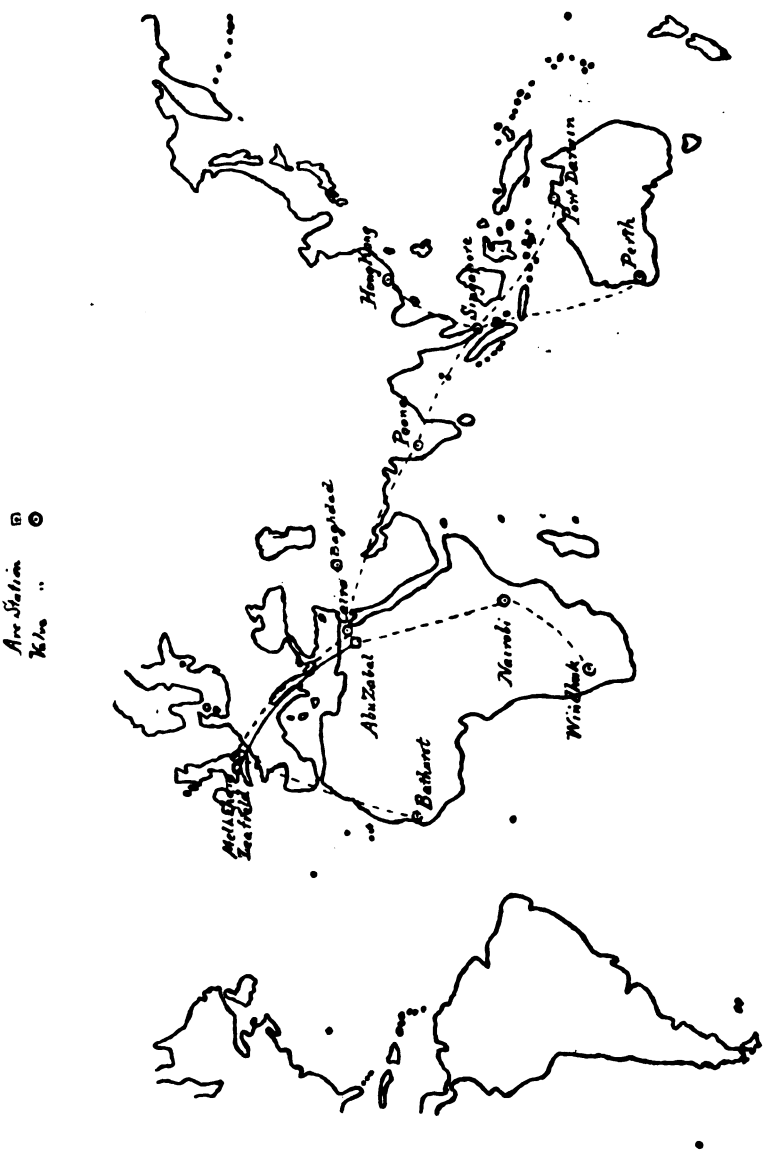
SCHEME 3.

Scheme I Revised and Revised by Sir Henry Norman's Committee, 1920.



again in 1899-1902) there is a steady yearly increase in the number of cables, it became evident, after four years of enforced inactivity through war, that in the matter of laying submarine cables the world had four years' leeway to make up.

Thus the demand for Imperial wireless communication became

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very pressing, and, in 1919, the Government again took up the project for an Imperial Wireless Chain, ordered the Post-Office to complete the two stations started by the Marconi Company, and appointed an Imperial Wireless Telegraph Committee under Sir Henry Norman to go into the whole question.

The Committee made several important recommendations (*v.* Scheme 3) :—

(1) That there should be two chains instead of one, viz.:—
  (i) Leafield—Abu Zabal—Nairobi—Windhuk.
  (ii) Melksham—Cairo—Poona—Singapore—Hongkong and Port Darwin (or Perth).
  with outlying stations at Bathurst and Baghdad.

(2) That the valve system be used throughout, except for the two Poulsen Arc Stations already nearly completed.

(3) That the Canadian Government be asked to confer with the Imperial Government as regards similar communication being provided with Canada.

(4). That the whole system be State-owned, a Wireless Commission of technical experts being appointed to design the stations and supervise them during construction, the work being carried out by the General Post Office and the corresponding Dominion and Indian authorities.

There are certain points in these recommendations which call for comment : —

(*a*) We were already committed to the Poulsen Arc for the two stations in course of erection. Since they were started, however, the valve, then in its infancy, had made such progress that the Committee decided in favour of having all the new stations equipped for valve-transmission.

(*b*) Instead of electing for high-power stations in England and in the distant Dominions, the Committee had preferred the idea of chains of stations, no link of which was longer than 3,000 miles.

(*c*) The Committee evidently had dropped the former idea that Canada was already adequately provided for.

(*d*) Although the work of providing the first wireless chain in 1913 had been given to Marconi's, that company was now to stand aside in favour of the Post Office.

There was, after this report was published in June, 1920, much furious discussion in the press, and it continued for two years. The arguments on the one side were all directed to the necessity of giving the work again to the Marconi Company.

They ran in a crude form something like this :—

(1) The Government plan being for short links, and not for stations of the highest power to maintain communication

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direct with all outlying portions of the Empire, including Australia, is a bad one.

(2) The Marconi Company has spent large sums of money on research work and experiments, and is better equipped for the task than the G.P.O.

(3) The Marconi Company, by combining with the American Marconi Company, the French General Wireless Company, and the Telefunken Company of Berlin, has secured all the necessary patents.

Against these were urged :—

(1) That, in accordance with the recommendations of the W/T. Commission, appointed after the Imperial W/T Committee's report, a new English station would be erected powerful enough to work with Australia direct, except during unfavourable atmospheric conditions.

(2) That, even though this might be the case, it was not sufficiently so to warrant a monopoly being given to any one Company, which could then stifle all competition to its own benefit ; and that, as there must be a monopoly, it had better be a State one.

(3) That many important patents were about to expire, and that in the case of others there were alternatives.

The Marconi Company made some powerful allies, not only by combining with the leading wireless companies in foreign countries, but also by entering into separate contracts with certain of the Colonies. The Company also started a great agitation in the Press, which was quite ready to take up the cudgels, complaining with reason, if not with understanding, of England's undeniably backward position in the provision of really high-power wireless stations, from which the Press, of course, suffered. Moreover, Marconi, while justifiably confident that they could fill the bill, had little reason to believe that the G.P.O. would be equally successful.

In January, 1922, the Imperial W/T Commission reported on plant and sites. They also made recommendations of a general nature, of which the most important was that England, Canada, Australia; South Africa and India should have stations of sufficiently high power to work to each other direct, except during unfavourable atmospheric conditions. In other words, the Commission did not support the Imperial W/T Committee's views on the Chain question (*v.* Scheme 4).

In July, 1922, the Government, following the technical Commission rather than Sir Henry Norman's Committee, took a decided step towards dropping the idea of a Chain, in deferring the Singapore, Hong-Kong and East African stations, and also the second station in Egypt. They selected Bourn, in Lincolnshire, as the site of the English high-power station, and substituted Johannesburg for

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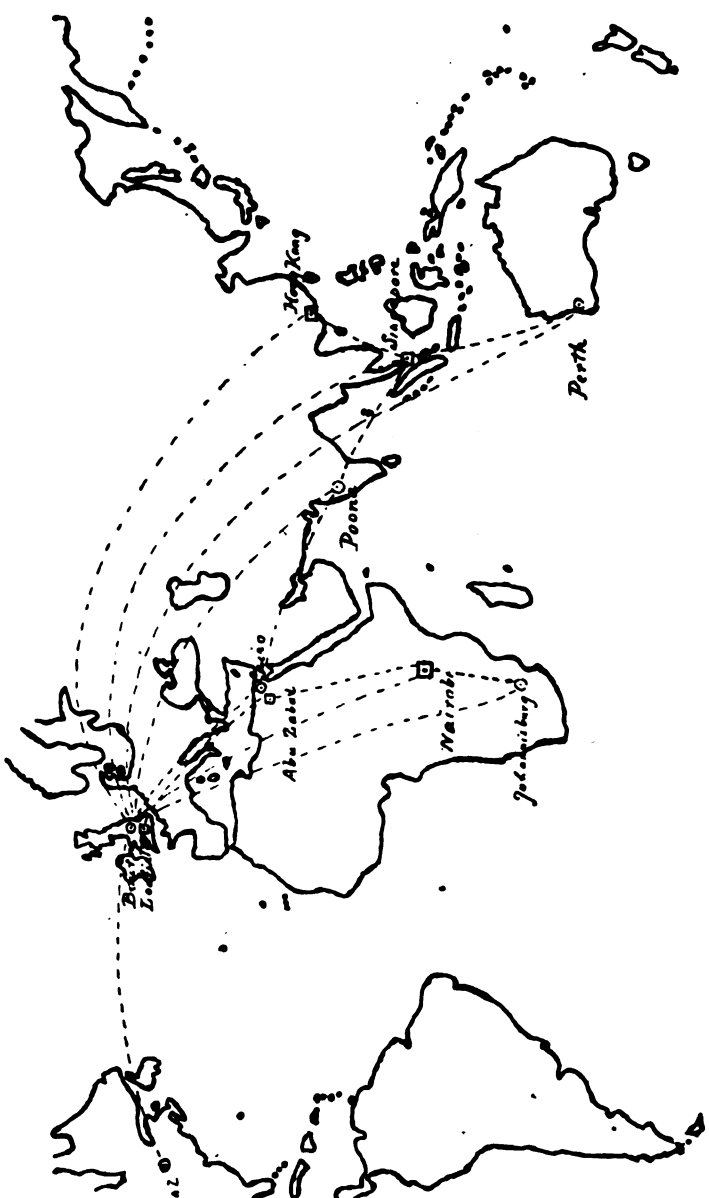

SCHEME 4.

Proposals of Lord Milner's Commission, 1922, marks transition from Chain to Long Range.

Windhuk, the advantages of the former as regards land-line communication being sufficient to outweigh the existence of the ex-German high-power station at the latter. The Postmaster-General told the House of Commons that the erection of the high-power stations in England, South Africa and India would start at once,

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and that Australia had already given a contract for the erection and operation of its high-power station to an Australian Company. As South Africa and India both made similar arrangements soon afterwards, the prospect of Imperial Wireless materializing at last began to look particularly bright.

There were, however, plenty of snags ahead.

On the recommendation of the I. W/T Committee, Government had decided that the whole scheme of Wireless communication should be designed by the State, erected by the State and worked by the Post-Office for the State. This decision was made in the days of the wireless Chain. When the idea of a Chain was dropped in favour of high-power stations working direct over the greatest distances, the idea of the State doing everything was abandoned in favour of permitting private firms to design, erect and operate certain stations, while the State confined itself to control, *i.e.*, distributing traffic and determining to whom and when each station should work. This concession was really making a virtue of necessity, since, by separate agreements with Canada, S. Africa, Australia and India, either the Marconi Company or companies affiliated to it had got into their hands all the Colonial terminals of the respective wireless channels.

The Post-Office intended then to run Empire Wireless, consisting partly of Government stations, and partly of private stations, under what came to be called the system of "unified control," *i.e.*, the Post-Office would accept all traffic, and distribute it to the appropriate stations for dispatch. It would also control, *i.e.*, decide, depending on the volume of the traffic, prevalence of atmospherics and the state of ionisation of the atmosphere (*i.e.*, which part of the globe happened to be in daylight) to which station any particular station should work.

These concessions did not go far enough to satisfy. Marconi's agreed to the principle of "unified control" only on the condition that the control was left in their hands, and not in those of the Post-Office.

This was a concession the Post-Office could not make. They were obliged to make another suggestion, a system of "regional (or territorial) distribution," under which the State and Marconi's would divide the Colonies between them, each retaining sovereign control over its own system. Specifically, Government was to work England to South Africa and England to Canada, while Marconi's put up in England two new stations, in addition to their station at Carnarvon, for the rest of the Empire. This proposal was a great come-down for the Post-Office, but again Marconi's refused. With supreme confidence, they countered with a proposal for free competition, and thus produced a deadlock which lasted nine months.

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In March, 1923, the Prime Minister (Mr. Bonar Law) announced :—

" In view of developments in W/T and other circumstances which have arisen since the late Government decided on a State-operated wireless chain, it is not considered necessary any longer to exclude private enterprise from participation in W/T within the Empire. Therefore, Government has decided to issue licenses for the erection of W/T stations in England for communication with the Dominions, Colonies and foreign countries, subject to conditions necessary to secure British control.

" At the same time Government has decided, in the interests of national security, that there should be a W/T station in this country capable of communicating with the Dominions, and owned and operated by the State. It will be available for commercial traffic."

In short, the Government had capitulated.

They had not only surrendered on the question of free competition, but had abandoned a policy, now eleven years old, of State-control in favour of " British " control, which, judging from the text of the announcement, must be taken as including control by a British company.

Marconi's, notwithstanding its foreign associations, was, of course, qualified under this head.

The dismay which the Prime Minister's announcement occasioned to the Post-Office, and among the supporters of the former Government policy, may be likened to the feelings of Rome on hearing of Cannae. The parallel goes further, for, as after Cannae, subsequent events quite failed to justify the apprehension felt. But this is to anticipate : the immediate result of the announcement was that Marconi's applied for a general license covering the Empire, and the Eastern Telegraph Company for one covering the wireless service between England and India.

The Postmaster-General made a number of counter-proposals, both interesting and formidable :—

(1) Marconi's to provide two high-power stations in England in addition to Carnarvon ; the Government to provide one high-power station in addition to Leafield.
(2) The whole of these stations to be worked by Government, Marconi's paying a share of the expenses.
(3) Revenue to be divided between Government and Marconi's.
(4) Unrouted traffic to be allocated to cables or to wireless, whichever would be quickest.
(5) Government to have the right to admit other companies to the pool.
(6) Government to retain its right to grant licenses to other companies outside the pool.
(7) Government to have the power of expropriation.

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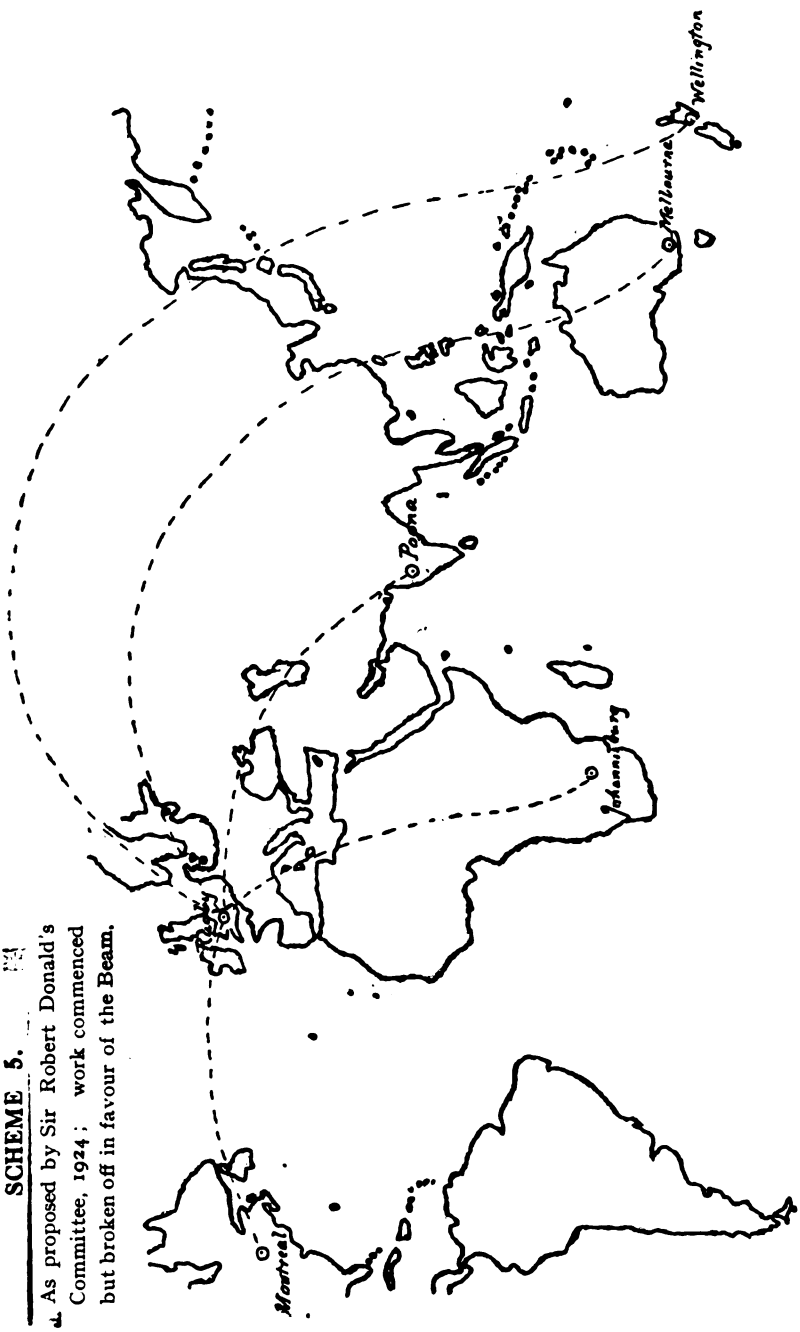

SCHEME 5.

As proposed by Sir Robert Donald's Committee, 1924; work commenced but broken off in favour of the Beam.

The deadlock which now resulted lasted for nine months, at the end of which time Government applied their usual last resort—a Committee. This Committee, known as the Imperial Wireless Telegraphy Committee, 1924, appointed at the end of 1923, did

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some swift and excellent work, and produced their report by the end of February (*v.* Scheme 5). Their chief recommendations were :—

(1) The State to erect, own and operate all wireless stations in Great Britain for communication with the Empire, except as far as Canada is concerned, the Canadian service being left in Marconi's hands.

(2) Private enterprise to be given all facilities to develop wireless communication with the rest of the world, *i.e.*, outside the British Empire.

(3) The Government wireless stations at Leafield and Rugby (for Empire communication) to be enlarged, and another high power-station erected without delay.

(4) The Government wireless station at Abu Zabal, near Cairo, to be given up when the new high-power stations in India, South Africa and Australia are working.

(5) The expert W/T Commission to report on an extension of Imperial wireless to include all the widely-scattered Colonies and Protectorates of the Empire, on the lines of the French Colonial wireless service. (NOTE :—This includes Indo-China, the West Indies, French Guiana, Réunion and Madagascar.)

The I.W.T.C., 1924, or "Donald's" Committee, "seeing no prospect of success on the lines of the policy which have been explored and discussed at much length and in great detail during the last nine months," thus felt themselves justified in recommending a reversal of Mr. Bonar Law's (March, 1923,) policy, and a reversion to the State-ownership idea.

In July, 1924, the Postmaster-General said that the recommendations of Donald's Committee were mainly accepted. We were thus back again at very much the same position as two years before, a position which led to the nine months' dead-lock that Mr. Bonar Law's proposed admission of private enterprise into Imperial Wireless failed to solve. In fact, the question of how to provide Imperial Wireless had become so knotted that cutting became the only solution. It was by the best of fortune that at this moment, when all seemed hopeless, there appeared an Alexander in the shape of Mr. Marconi. The sword with which he cut the tangled knot was his invention of Long-distance, Low-power, Short-wave Directional Wireless, better, more shortly, and more appropriately known as "the Beam."

DIRECTIONAL WIRELESS.

Before showing how the situation was thus dramatically saved, it will be necessary to say a few words about Directional Wireless. When the Beam was invented Directional Wireless was, as wireless goes, already an old story. It is almost unnecessary to say that

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it, also, was an invention of Marconi. It was he who discovered that a single vertical wire aerial (or a symmetrical aerial like the T-aerial) radiates energy equally in all horizontal directions, and that the converse also applies, viz., that such an aerial used for reception is affected equally by energy arriving from any horizontal direction. Further, he discovered that these properties are peculiar to symmetrical aerials, while all unsymmetrical aerials radiate waves of different intensities in different azimuths, and conversely receive greater or less amounts of energy from waves arriving from different directions.

In 1905 Marconi patented the reversed—L directional aerial, consisting of a single vertical wire (or row of such wires) with a much longer horizontal portion (or portions) pointing away from the station to which it is desired to transmit or from which it is desired to receive. Such a bent aerial radiates most strongly (and receives best) in its own plane, and in a direction opposite to that to which its horizontal portion points. Experiments appear to prove that the energy radiated or received by an inverted-L aerial thus set up is five times as great as would be the case with an aerial of the same size symmetrically arranged. It is not surprising, therefore, that, wherever the nature of their work permits, long-range wireless stations have widely adopted directional aerials for transmission as well as reception. It was so obviously uneconomic to expend energy in sending signals where they were not required, that, the directional principle having been found possible of application, much time and thought were given to the subject.

The next development of directional wireless originated, however, in a discovery of another sort.

Frame-Reception.

It was found that wireless signals, in addition to being received by means of the ordinary type of overhead aerial, either earthed or having instead of an earth a counterpoise or lower capacity, could be received upon an aerial of an entirely different type, viz., a closed coil or loop having no earth connection.

In order to understand how it is possible to receive wireless signals by means of two such widely-differing types of aerial, it is necessary to consider the nature of the wireless wave itself which carries these signals. Whatever the origin of the electro-magnetic wave, in its higher frequencies as radiant heat, light, actinic-ray, Röntgen- or Millican-ray, as wireless-message-carrier, it originates in the interaction of the two essentials of an oscillating circuit, capacity and inductance. When current is oscillating there are produced alternately a static field at the condenser or capacity-area, and a magnetic field round the inductance. As the currents oscillate in this circuit the fields (static and magnetic) are formed and die away

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alternately, *i.e.*, they pulsate outwards from and in towards the seat of the oscillations. It will be noticed that so far there is no question of radiation, but at a distance of about a quarter of a wave-length from the oscillating circuit, radiation actually starts through certain minute portions of energy (electric and magnetic) becoming associated to form an electro-magnetic wave. These minute portions of energy are by the inertia of the ether, so to speak, flicked off from the pulsating fields and travel together outwards with the velocity of light. The two components, electric and magnetic, of an electro-magnetic wave, are equal in energy, oscillate at the frequency of the wave, at right-angles to each other, and at right-angles to the direction of the wave. It may assist in getting a mental picture if we look upon the wireless wave as originating at the centre of a globe and as having reached the surface of it. Then, at any point on the surface the direction of travel of the wave is along the radius to that point. At right-angles to the radius, and at right-angles to each other, are the parallels of latitude and longitude. The magnetic component's oscillation is along a parallel of latitude and the electric component's oscillation is along a parallel of longitude.

The electric component is generally vertical in its oscillations. It is thus best intercepted by a lineal conductor (overhead aerial), placed horizontally, and pointing to the source of the wave. The magnetic component is generally horizontal in its oscillations. It is thus best intercepted by a coil or loop (frame-aerial) placed vertically and in the same plane as the source of the wave. The frame-aerial and the ordinary overhead aerial are thus two different means of trapping the wave in order that the receiver may discover its secret. They are alternative means, since each of them absorbs energy from one particular component of the wave, allowing the other to pass.

When the properties of the frame-aerial were noticed, signals were found to be so much weaker than with overhead aerials that the frame-aerial would have received little attention, but for the fact that it was strongly directional.

An aerial capable of rotation into the position of loudest signals was not only desirable for receiving from moving stations like ships and aircraft, but was the foundation of special departments like the wireless compass-stations which worked under the General Staff (Intelligence) in the war, locating enemy wireless-stations, and like the coastal d. f. service, which locates ships at sea and—for a small fee—gives them their bearings. An alternative to the latter is when the moving station (ship or aircraft) is itself fitted with directional apparatus. If it can then receive from two fixed stations in known positions, and if they are favourably placed for reception, the moving station can plot its own position.

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The first trouble of the frame-aerial was weak signals : the second was that when it was increased in size in the interests of increased signal-strength, it soon became unwieldy. This trouble was brilliantly surmounted by the invention of the Bellini-Tosi aerial, in which two frames are mounted at right-angles, and so fixed, the necessary rotation being done not by the frames but by a small coil inductively coupled with coils in the horizontal lower portions of the two frames. When oscillations are set up locally in the movable coil, the resultant radiation of the two aerials is a maximum in the direction in which the moveable coil is pointing. Similarly for reception, the fixed frames pick up energy according to their positions relative to the direction of the incoming wave, and the movable coil by maximum (in some patterns minimum) strength of signals indicates that direction. But valuable as the Bellini-Tosi aerial was to directional wireless in general, and to reception on a loop in particular, the most valuable invention was still to come. What established loop-reception and the frame-aerial was valve-amplification, part of the phenomenal progress in wireless due to the imperative demands of war and its lavish expenditure. There is now no complaint about the frames being unwieldy, since current-amplification by means of valves has brought long-range reception (*e.g.*, Europe from America) within the scope of loops wound on frames no larger than eight feet square.

Enough has been said to show that, when Marconi invented the form of directional wireless known as the Beam, directional wireless itself was already both established and widely spread.

The Beam.

The Beam is often likened to the search-light. As regards the transmission-end the likeness is a good one, but it does not go far enough, since an essential part of the Beam is the collection and focussing of the rays at the reception end.

When the Beam was invented this reflection and direction of the rays at one end and collection and focussing of the rays at the other end was a novelty only as regards long-distance working. In itself, apart form this, it was the oldest form of directional wireless known, having formed part of the original experiments of Hertz, Lodge and Marconi. And, indeed, this was bound to be the case. It is barely conceivable that a scientist endeavouring to produce radiation and to detect it, should neglect such a simple means of increasing the effects he desired to obtain. The simplicity of the means lay in the fact that all good electrical conductors being opaque to wireless waves, all that was necessary to increase effects in these experiments was to place radiator and receiver in metal boxes, each box having an opening facing the other box.

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Hertz, in 1887, used two zinc boxes, each with a curved side facing the open side. He showed when the open sides of the boxes did not face inwards, that by means of a metal plate, or a prism, he could reflect, or refract, the radiation from one box into the other.

For interference experiments he improved on the metal-boxes by using parabolic mirrors of zinc. A paraboloid of revolution as used with the search-light, on account of the light emanating from (approximately) a point, was not necessary. As the radiation emanated from an oscillator, say, a yard long, a parabolic cylinder was used instead, having the oscillator in the focal line.

Marconi, in his early experiments placed his Righi oscillator in the focal line of a parabolic reflector, and for reception a coherer at the focus of a second parabolic mirror.

The development of these experiments into commercial wireless telegraphy, *via* the grounded oscillator and high aerials, took place in a direction that led away from the use of reflectors. Wave-lengths were increased in order to get greater ranges, not because the longer wave-lengths were more efficient as regards the expense of energy, since the reverse is the case, but because the longer waves were more successful in surmounting obstacles and suffered less from attenuation.

With the use of longer wave-lengths the mirror ceased to be effective, since its size should, in any case, be not much less than the wave-length, and for the best results it should be larger.

The use of reflectors was thus dropped for some twenty years, until, in 1916, Marconi took the subject up again for a special purpose. Secret wireless had been demanded for war purposes, and Marconi started investigating what could be done with very short waves (2 to 3 metres). For such wave-lengths he naturally revived the reflector. He used a spark-transmitter in a closed oscillating circuit, transformer-coupled and crystal-reception, and got a range of two miles. Then, by adding cylindrical parabola reflectors of vertical wires tuned to the wave, and with apertures of $3\frac{1}{2}$ wave-lengths, he increased the range from two to six miles. These trials were made in Italy. In 1917, under his instructions, the experiments were continued at Carnarvon, and the range was increased to twenty miles. It is not known whether any war use was made of these results, but, owing to their excellent directional effect, they were quickly applied to navigation in the shape of the radiophare or wireless light-house. A trial was made at Inchkeith Island, where a revolving parabolic reflector sent every two minutes a signal to every half-point of the compass, efficiently piercing fog up to a range of ten miles for any ship with a wireless eye in the form of the appropriate receiver.

When the war was over, the experiments with short waves continued, but with a new object, viz: to determine the feasibility of directional

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telephony, the necessary continuous wave being provided by changing to valves. With a wave-length of fifteen metres and a reflector of half a wave length aperture Marconi's assistant, Mr. Franklin, got speech sixty miles to Kingstown Harbour. This was a great success, because he was working over the horizon, in other words, the Beam, instead of being directed away into space, was behaving like undirected wireless, *i.e.*, arriving at its destination in spite of the earth's curvature.

Stations were then erected 97 miles apart, at Hendon and at Frankley, near Birmingham, and more trials were carried out, including the successful working of duplex, *i.e.*, sending and receiving simultaneously on the same aerial and the same reflector, thus not only doubling the performance, but eliminating all switching-over.

Although Marconi had proved by this time that wave-lengths of the order of twenty metres could provide a point to point directional service at a considerable range, adequate for commercial requirements,he came to the conclusion that for the longest distances, such as Imperial wireless necessitates, longer (but still short) waves were desirable.

During 1923, a series of trials were carried out on 100 metres, between a special plant at Poldhu and Marconi's yacht, the *Elettra*. The popular ideas about short waves at the time were, that they were bad travellers over land and mountains, that their range in daylight was short and unreliable, and their range in darkness, though longer, was still unreliable. It was true that there had been plenty of evidence to shake these beliefs in the U.S.A. to Great Britain amateur trials of 1921 and 1922, but there was a tendency to regard the results of these trials as " freaky " rather than to see in them a confirmation of the very sound lines upon which Marconi was working. The amateur trials certainly indicated that our ideas on the power necessary for range needed revising. High-power stations had grown from the 30 kilowatts, first used for spanning the Atlantic, to the 500 and even 1,000 kilowatts, now used for the same purpose ; a growth which had proceeded mainly on the principle of smashing through at all costs—to others. The widespread successful reception in Great Britain of signals from American amateurs who were limited to 1 kilowatt, and many of whom were using less, and the results achieved by Marconi over much longer ranges with 20 kilowatts, which include telephony, incline one to wonder whether, except when required expressly for broadcasting, the 1,000 kilowatt station of the present will not join the mammoth and the megatherium.

The *Elettra* trials with Poldhu proved that all the popular ideas mentioned above regarding short waves were incorrect, at any rate as far as 100 metres was concerned. The signal-strength at 820 miles, with the whole of Spain intervening, was reported the same

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as in Falmouth Harbour when the yacht was only twelve miles from Poldhu. The *Elettra* was worked to on 12 kilowatts as far as the Cape Verde Islands (2,230 miles), although the yacht itself had no reflector.

Trials were continued the next year, being extended to South America and to Australia, and in June, 1924, wireless speech was received in Sydney from Poldhu by means of the Beam on 100-metre wave, using 30 kilowatts only, as compared with the 1,000 kilowatts (12½-mile wave) previously used for a similar performance.

THE BEAM FOR IMPERIAL WIRELESS.

But meanwhile, in 1923, the Marconi Company had gained sufficient experience of Beam-working, and was ready with a proposal to Government, which effectively cut the Gordian knot. On March 1st, at the very moment of issue of the Donald Committee's Report, they claimed in the Press the following advantages for the Beam as compared with High Power:—Marked reduction in the initial cost of stations, decreased cost of maintenance, and a far greater speed of working. Increased secrecy, owing to the Beam being dispersed over 30° instead of 360°, was also claimed, but, although this is not without value for Imperial as opposed to commercial purposes, secrecy in matters political or strategical is rather an absolute than a relative matter, and the real advantages in diminished dispersion are:—

(i) Less interference with other stations; hence an increase in the total number of stations possible. This is a most important point in view of the rapidly-increasing number of stations in the world, and the consequent congestion on the limited number of wave-lengths available.

(ii) A vast saving of energy; thus a 30° dispersion Beam would produce the same effect as non-directional wireless with 30/360 = one-twelfth of the power. A reflecting system at the receiving-station would effect the same ratio of concentration, thus making possible a further reduction to one-twelfth of the power, or to 1/144 in all.
With narrower Beams this saving rises very high.

(iii) Much reduced liability to suffer from atmospherics and from interference by other stations.

Before the Royal Society of Arts in July, Marconi claimed his discovery of the generally unsuspected fact, that short-wave wireless with lower power gives far better results than the system upon which wireless development had hitherto been concentrated, as a "revolution." Upon the results as announced to the public this claim may be conceded.

The Government, no doubt swayed by the deadlock in Imperial Wireless as regards high-power stations, and tempted by the vastly

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reduced cost of beam-stations (less than one-quarter that of high power stations), quickly accepted the Marconi Company's proposals, an acceptance even then anticipated by a leading newspaper in the somewhat ungracious words :—

"It would appear, therefore, that some advantage has accrued, after all, from the otherwise deplorable delay in establishing the Imperial Wireless Chain."

The Postmaster-General announced in the House of Commons only twenty days later :—

(1) Government had accepted the two main recommendations of Donald's Committee as regards the State owning all Imperial Wireless stations in England and the Post-Office working them.

(2) That the Marconi Company had put forward proposals for working by Short-wave Directive, or Beam, from England to the Dominions and India, and were willing to co-operate in whichever system might be adopted.

(3) That the Marconi Company had already entered into an agreement with the Canadian Government to build a Beam station in Canada for communication with England, and that, with the House of Commons approval, he (the P.M.G.) would enter into an agreement with Marconi's for a Beam-station in England to work with Canada. If trials were successful, such stations to be bought by the State for £58,000, and further stations to be built for communication with South Africa, India and Australia, at £36,000 each.

(4) That the Marconi Company's guarantee, included in contracts, was a speed of 100 words per minute for the following number of hours a day, based upon the sun's mean altitude :—With Canada, 18 hours ; with India, 12 ; with S. Africa, 11 ; with Australia, 7.

(5) In order to have wireless communication at all hours and for simultaneous working in all directions at all hours (considered essential for strategic and other reasons) high-power stations of the Rugby type would still be necessary, and the wireless station at Rugby would need to be extended.

There was a certain amount of grumbling in the newspapers over these announcements, and hard words were used about the "restraining shackles of a Government monopoly," but there was general satisfaction that the long struggle as to how Imperial Wireless was to be provided and how worked was at last ended. Not only the Government and the public were satisfied at the settlement, the other two parties had also grounds for satisfaction, the Post-Office, as having gained the control on which they had insisted through thick and thin, and the shareholders of Marconi's when they were

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informed that their Company had contracted to erect the Beam-stations in England at a profit of 10% plus 5% overhead charges, and would receive 6¼% royalty on all takings for wireless messages, an arrangement "likely to produce a substantially greater revenue" than would have been gained under the cancelled contract of 1913.

THE NEW STATIONS.

The trials between England and Canada referred to by the Postmaster-General in July, 1924, were successful. Contracts were made accordingly, and work started on all the Beam-stations in England forming part of the Imperial Wireless scheme. The Dominions and India contracted at the same time with Marconi's for their own stations for this service.

The following unofficial list gives what is believed to be the present state of affairs :—

IMPERIAL BEAM-STATIONS.

Service.	In.	For.	Transmission.	Reception.	State.
1	England	Canada	Bodmin	Yamachiche 25 m. N. of Drummondville	Opened 25/10/26
	Canada	England	Drummondville 35 m. E. of Montreal	Bridgwater	
2	England	S. Africa	Bodmin	Milnertown, near Capetown.	Due for opening early in 1927
	S. Africa	England	Klipheval, near Capetown	Bridgwater	
3	England	Australia	Tetney, near Grimsby	Sydenham, 15 m. from Melbourne	P.M.G. said on 9/12/26 "trials hoped to be completed in some weeks."
	Australia	England	Ballan, 50 m. W. of Melbourne	Winthorpe near Skegness	
4	England	India	Tetney, near Grimsby	Near Poona	Due for opening early in 1927
	India	England	Near Poona	Winthorpe, near Skegness	

To which should be added :—

PRIVATE BEAM-STATIONS OF IMPERIAL VALUE.

5	Australia	Canada	Ballan, 50 m. W. of Melbourne	Yamachiche, 25 m N. of Drummondville	Owned by Canadian and Australian Marconi Co.'s.
	Canada	Australia	Drummondville, 35 m. E. of Montreal	Sydenham, 15 m. from Melbourne	

This service, by relay at Montreal, provides with Service 1 an alternative to Service 3.

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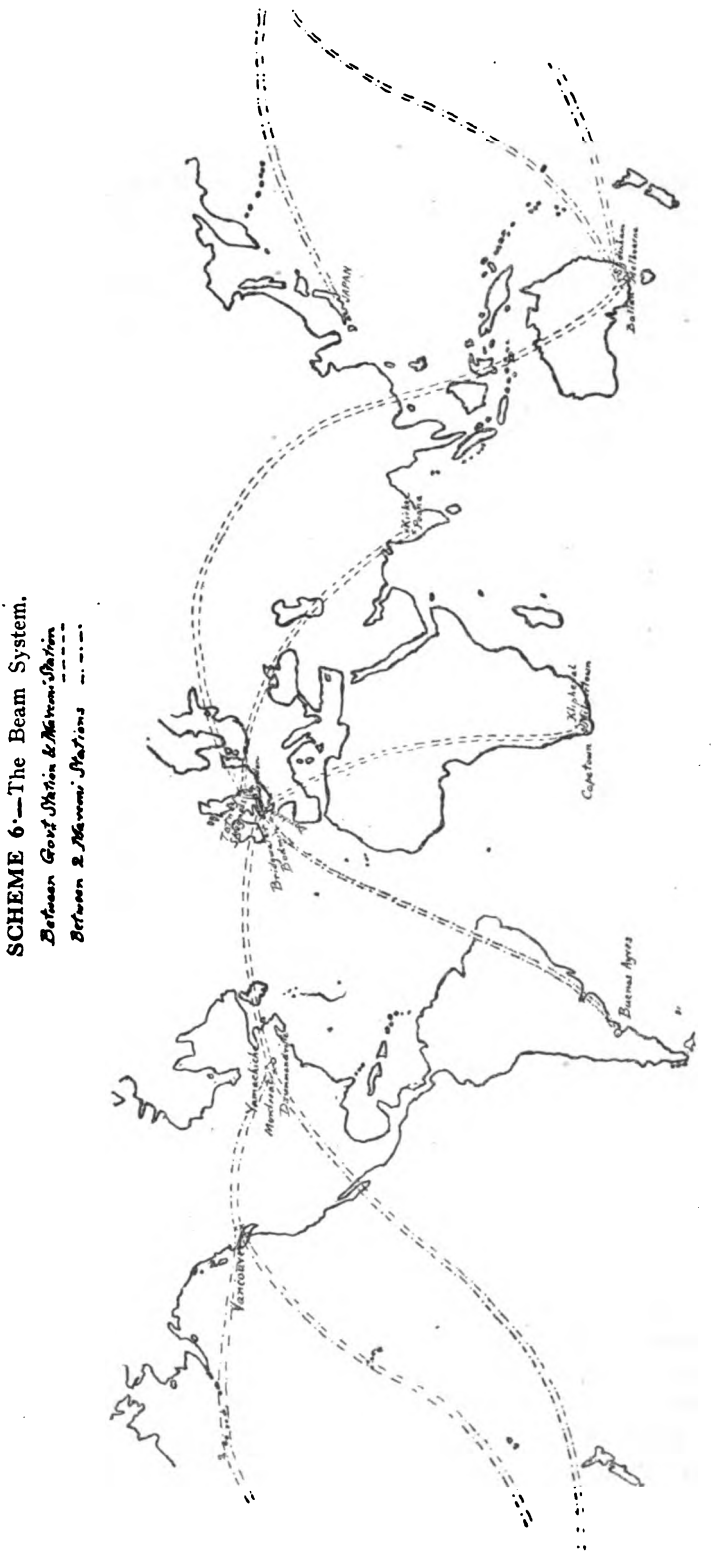

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IMPERIAL HIGH POWER STATIONS.

1. Leafield, built as part of 1913 Imperial Wireless Chain ; since enlarged ; works with ships ; sends Press telegrams to Nova Scotia, Egypt and India, and broadcasts British official communiqués.
2. Rugby (Hillmorton), built as part of Mr. Bonar Law's 1923 scheme ; since enlarged ; can work to ships in every part of the world.

As regards the high-power stations which should have been erected to communicate with Rugby :—In South Africa, work had actually started on a high power station, but was stopped owing to favourable representations of the Beam system : in Australia, negociations as regards providing a high power station were broken off in favour of a Beam-station, although the Commonwealth Government had been advised by the British Government to provide stations of both kinds; in India, the company which had tendered for a high power station was allowed to withdraw its offer and to tender for a Beam-station instead.

The utility of the large Government wireless station at Rugby has thus been curtailed. It can still be of the utmost importance for communication with ships and for broadcasting, since reception of its messages can easily be arranged in all British possessions.

As regards the list of Imperial Beam Stations, certain points will be noticed. For each service there is at each end a pair of stations, one for transmission, and one for reception. This separation of transmitter and receiver, combined with directional transmission, is the usual practice for all long-range high power services, in order to obtain duplex working ; thus Marconi's high power station at Carnarvon has its receiver at Towyn, thirty miles away, while the Government high power station at Leafield receives at Banbury. The grouping of transmitting stations in pairs, and of receiving stations the same, is done for administrative purposes.

In addition to being duplex, the stations all work High Speed Automatic, being operated by perforated tape previously prepared by hand, guaranteed speed=120 w.p.m., or 240 duplex, *i.e.*, 144,000 words in a ten-hour working-day. Against this the best cables to America average 25 w.p.m. (hand speed), for a 24-hour day, *i.e.*, 36,000 words per day. Hence the Postmaster General was able to announce in July, 1926, that (except for Canada) there would be a reduction of one-third on the cable rates existing in July, 1924, or 8d. a word less to South Africa, 7d. a word less to India, and proportionate reductions on Press telegrams.

In the comparison between cables and wireless, ten hours has been taken as the working-day of the latter, owing to the limitations laid down in the Marconi Company's guarantee of the Beam system in 1924, but it appears from the Press that subsequent technical

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improvements have allowed a 24-hour day to be substituted, even in the worst case as regards daylight interference, viz., England to Australia, for which the original guarantee was only seven hours in the twenty-four.

High Speed transmission implies High Speed reception, both being above the capabilities of the human operator. Signals on the receiver are transferred by land-line to a central office, where the message is recorded automatically by tape perforations, and the perforated tape is then passed through a printing machine which converts the message into Roman characters on strip, ready for pasting on telegraph forms.

In the case of all Beam stations in England the Central Telegraph Office in London will operate both transmission and reception by "remote control," *i.e.*, through land-line. In Canada the same system will apply at the offices of the Canadian Marconi Company in Montreal. Similarly the transmission from Ballan will be keyed at a central office in Melbourne to which the reception at Sydenham is led in by land-line.

Reflectors are of the same type at transmitting- and at receiving-stations. They are believed to consist either of a series of vertical wires suspended equally spaced along a parabola of which the aerial occupies the focal line, or the aerial itself (one wave-length high) consists of a number of vertical wires suspended between masts occupying points on a parabola, one wave-length apart, while the reflector, consisting of similar sections of vertical wires, is placed parallel to the aerial and at a distance of a quarter wave-length behind it. This distance permits both aerial and reflector to hang from 40 ft. horizontal arms carried by a single row of masts.

The dispersion from one section of such an aerial (being of a symmetrical type) is 360°. The effect of the reflector placed parallel to it and a quarter wave-length away is to make the aerial uni-directional, *i.e.*, its dispersion is reduced to 180°.

If four such sections, complete with reflecting screens, are placed along a parabola, practically all the energy radiated is confined within an angle of 30°. Twenty sections can even reduce the angle of dispersion to 6°. Equal areas of aerial at the transmitting- and receiving-stations are essential, as it is calculated that 500 times the magnification is given by having a 10 square-wave-length aerial at each end, as against having a 20 square-wave-length aerial at either end.

Where unity represents the energy received under similar conditions from a simple vertical aerial one-eighth of a wave-length high, the magnification claimed for a Beam-aerial twelve square wave-lengths in area, with reflecting-screens, at both transmitting- and receiving-station is 14,000.

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FEEDER SYSTEMS.

In densely-populated England, where land-line telegrams (or at least phonograms) can be despatched from post-offices in the smallest villages, it is not always easy to get people to realize that long-distance wireless to Britain's chief possessions is only the beginning of the matter. Where different conditions prevail, where territories are vast and population is scattered, it is fortunate that the Governments are alive to this fact. Four years ago Australia, owing to the enterprise of the Commonwealth Government and of the Australian Marconi Company, had a system of over thirty wireless stations distributed over the continent, and including New Guinea, King and Flinders Islands. The whole scheme embraced the Solomon, Fiji, Gilbert and Ellice Islands. In February, 1920, the Marconi Company had brought out a pamphlet working out in great detail a proposal for a network of wireless communication to serve the needs of the whole British Empire. Under such a scheme, communications between Great Britain and a Dominion would be by a wireless trunk, the terminals being called Main Trunk Stations.

Each Main Trunk Station is connected by land-line to a Central Control Office, to which is connected also by land-line a Main Feeder Station. The M.F.S. works by wireless with Local Feeder Stations in all suitable places. The L.F.S. works to the Main Feeder Station, and is also equipped for working to Small Local Stations.

The system is duplex throughout, except between Local Feeder Stations and Small Local Stations, where simplex is considered sufficient.

These ideas were considered by Sir H. Norman's Committee, and thoroughly turned down by them on the grounds that the Feeder Systems could only duplicate existing postal and telegraphic arrangements. A possible reason for such an opinion has been indicated above. The Feeder System, so far from being unnecessary as duplicating existing arrangements, is indispensable for linking up outlying possessions. This fact was tardily recognized when, stimulated by East Africa, Singapore and Hong-Kong dropping out of the Imperial Wireless Scheme, Sir R. Donald's Committee inserted as their last recommendation, that the W/T Commission should "report on a wireless system for the Colonies to complete the Empire network."

The Feeder System is equally indispensable in the vast spaces of Australia, Canada, and South Africa, where land lines either do not exist or are difficult to maintain. It would, in Great Britain, where telegraphs abound, be of a different character, having its Local Feeding Stations at continental capitals, thus providing the Imperial Wireless Service with points of contact with the outside world. Important as this would be for Press and commercial purposes, it would be of inestimable significance for introducing

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to the Colonies the European atmosphere necessary for an understanding of Great Britain's position as an European power.

Whether this idea materializes or not, the Colonial Feeder Systems are being got on with by the Colonial Governments. Pretoria Post Office will operate a transmitter at Roberts' Heights, communicating with Salisbury, in Rhodesia, thus relieving a long land-line through unpopulated country in Bechuanaland. This is only the beginning of a scheme for connecting Pretoria by Beam with all the principal centres in the South African Union. Similarly, the Australian capitals, Sydney, Brisbane, Adelaide, Perth, Hobart, and probably Canberra and Darwin, will be equipped as Beam Local Feeding Stations. The Feeder Systems are thus growing *pari passu* with the Trunks.

A great step forward was taken when the England-Canada Beam Service passed the official Post-Office tests between October 7th and October 14th, 1926, sending 250 words per minute duplex for eighteen hours on end, and averaging 130 words per minute for the whole seven days. The Service was opened for public use on October 25th.

Considering how slow Great Britain was in getting off the mark in the matter of wireless communication with the rest of the Empire, and how far behind the United States and France we have been in this respect, it is interesting to record the opinion of the *Times* that the completion of the Imperial Beam Stations now imminent, taken together with the high power station at Rugby, "will give Great Britain the most complete wireless service in existence."

Sources of information:—

(*a*) The daily press, especially the *Daily Telegraph* and the *Times*.

(*b*) Government publications:—
Report of Imperial W/T Committee, 1919-20.
Report of W/T Commission, 1922.
Report of Imperial W/T Committee, 1924.

(*c*) Marconi W/T Company's publications:—
Proposal for Wireless Network for the British Empire.
The Beam System for Long-Distance Communications.

(*d*) Several articles in *Modern Wireless*, most of them by Lt.-Col. C. G. Chetwode-Crawley, R.M.A., Deputy Inspector of W/T, G.P.O.

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THE SHANNON HYDRO-ELECTRIC POWER DEVELOPMENT.

By LIEUTENANT J. V. JENKINS, R.E.

The following notes were compiled after a visit to the Shannon Scheme late in 1926. By the time they appear in the *R. E. Journal* they will be in some respects out of date, as the work is making rapid progress, but they serve, nevertheless, to give an outline of a very important project, and may be found of some general interest.

I. INTRODUCTORY.

The excessive cost of coal has of recent years quickened the interest both of the general public and of engineers in the development of water power in the British Isles. The outcome of this increased interest, apart from sometimes ill-informed comment in the daily press on the subject, has been the production of numerous schemes for hydro-electric development. The majority of these, including the much-discussed Severn project, were not destined to come to fruition, but the schemes for the development of the Shannon were more fortunate. The Government of the Irish Free State, influenced partly by the fact that all coal has to be imported, decided to proceed with the most promising of the projects, the contract for the civil engineering work being given to Siemens-Bauunion in August, 1925. The electrical part of the work is being carried out by Siemens-Shuckert under a separate contract.

II. GENERAL OUTLINE OF THE SCHEME.

The Shannon, which is the largest river in Ireland, flows for the greater part of its course through country which is too flat for the economical development of water power. For some miles above Limerick, however, the fall is relatively rapid, and it is this fall which the present scheme is designed to utilise. The following brief notes may be best understood by referring to the General Sketch Plan (Fig. I).

Headworks.—A weir is being built about a mile and a half above O'Briensbridge, obstructing the river at a point where there is a bend, and the waterway is relatively narrow. The bend allows the water to flow into the Head canal leading to the power station in a natural straight line; further, owing to a fault in the strata, the

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rock comes very near the surface at this spot, so that little excavation is called for in making the foundations. The average depth of the river at the site is 12′, and the velocity of the current when in spate reaches 8 ft. per second.

The weir is to be constructed of Portland cement concrete, the compact sandstone which abounds in the district forming the aggregate. The concrete, which is to lie on top of the rock without any further excavation, will be placed round a steel framework, composed of tubular uprights at about 10′ interval, anchored to the rock by 18″ steel spikes cemented into bore-holes. A view of the coffer-dam, which is being constructed in three stages, and gives access to the river bed, is shown in Photo. I.

When finished, this weir will raise the water level of the Shannon to the average winter level of Lough Derg, and will be 200 yards long. This means that embankments will have to be built not only immediately above the weir, where a large area of more or less worthless country will be flooded, but also round the greater part of the Lough itself, as the district is already water-logged in winter. The fact that the river will be kept within bounds is one of the incidental advantages of the scheme.

Pondage.—In addition to the water impounded between the embankments above the weir, where a storage basin about half-a-mile wide will be formed, the contents of Loughs Allen, Ree and Derg, through which the Shannon flows, will be available as a reserve. The total present storage capacity of the three lakes is estimated by the contractors at 11,630 million cubic feet, and this could be more than doubled by increasing the height of the embankments and building additional weirs at the outlets of the two upper loughs. It is interesting to note that this storage capacity is equivalent to approximately twenty million K.W.H. at the average head available of 100 feet.

Head Canal.—The water will be taken from above the weir to the power-station at Ardnacrusha by a canal $7\frac{1}{4}$ miles long, of modified trapezoidal form, 264 feet wide at high water level. (See Type Cross Section, Fig. 4).

For the partial development at present contemplated, the canal has been designed for a flow of 8,475 cusecs, and the cross-sectional area being 5,104 sq. ft., the mean velocity will be 1.1575 ft./sec. The head available at the power-station is 100 feet, and the maximum output will therefore be about 56,500 K.W. This is half the total output obtainable from the Shannon, but provision has been made in proportioning the canal, for doubling the flow by raising the level of the water, and this will be done if and when it becomes expedient, from the commercial point of view, to instal more plant.

The small tributaries of the Shannon, which are prevented by the embankments from flowing into the river, are to be collected

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into a channel running parallel to the embankment, as indicated by the chain dotted line on the general plan. A reinforced concrete culvert takes the water from the channel under the head canal into the Shannon. The Blackwater River, which crosses the line of the canal about a mile above the power-station site, is provided with a similar culvert, the upstream entrance of which is shown in Photo. 2.

The canal is spanned where required by a standard type of reinforced concrete bridge, and will be available for navigation. Photo 3 gives a view of the canal under construction.

Power Station.—The Power Station, which is sited at Ardnacrusha, will be equipped with Reaction Turbines of the Francis type, operating at an average head of 100 feet, and drawing water from the forebay through reinforced concrete pipes. The turbines will discharge into the tailrace, $1\frac{3}{8}$ miles long, which returns the water into the Shannon about a mile above Limerick. (See Fig. 1).

When the development is complete, there will be a total installed H.P. of 180,000, but, for the present, only three sets of 30,000 H.P. each are being provided for, as it is not considered that the Irish Free State will require the whole possible output in the immediate future.

An idea of the size of the excavations may be gathered from Photo. 4, which shows a steam shovel at work on the foundations. The spoil excavated, which at the time of writing is a stiff boulder clay, is removed partly in tip-waggons directly along the bed of the future tailrace, and partly by cable crane to the railway running beside the head canal; it is used in the construction of the embankments.

To give a certain amount of regulation at the power station, in addition to that provided at the weir, a channel for waste water is to be made (Fig. 2), while a series of locks will afford a means of raising ships of 150 tons from tailwater to headwater level.

Transmission of Energy.—Power will be transmitted to Dublin and Cork at 100,000 volts, and to the rest of the country at 38,500 volts. Subsidiary transmission lines will supply distant localities at 10,000 volts.

III. Temporary Works at Ardnacrusha.

The temporary works necessitated by a project of this size are naturally very extensive, and are particularly interesting to military engineers. The field headquarters of the scheme are near the site of the permanent power station at Ardnacrusha, and to facilitate supervision, distribution of power to the works, &c., the workshops, stores, and other temporary structures are concentrated at this point. (See Fig. 2, lay-out of works at Ardnacrusha).

Accommodation for Staff and Workmen.—This comprises, in addition to the usual works offices, two hutted camps, one for 750

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PHOTO. 1.
Cofferdam at the Weir.

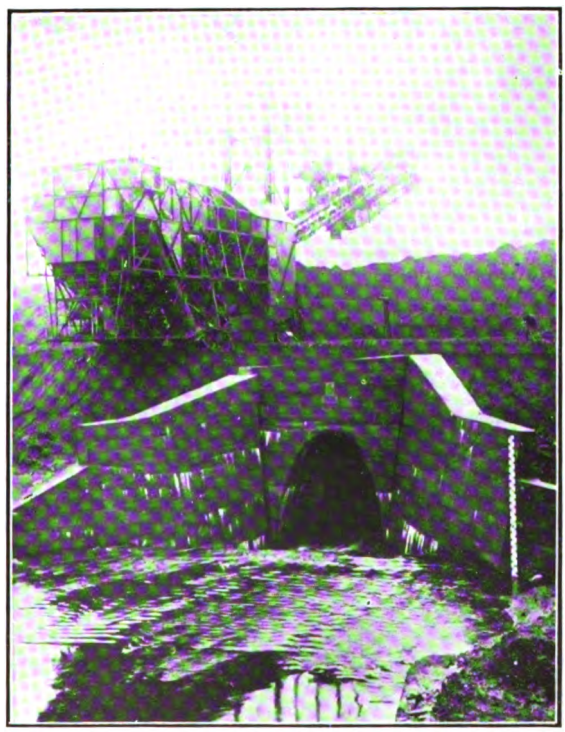

PHOTO. 2.
Entrance to Blackwater River Culvert.

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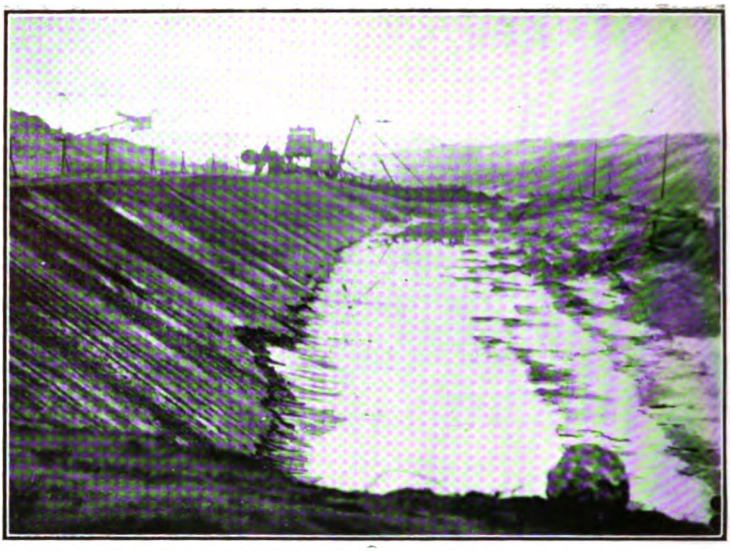

PHOTO. 3.
Head Canal under Construction.

PHOTO. 4.
Excavations at Power Station Site.

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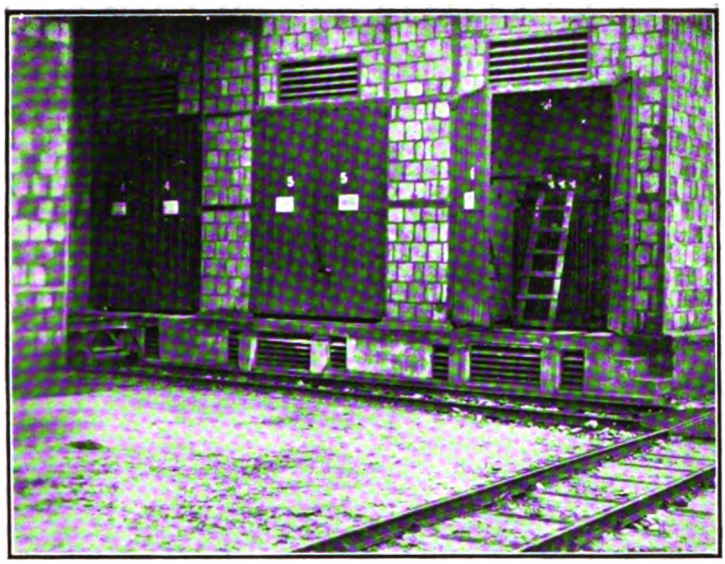

PHOTO. 5
Transformer House [Temporary Power Station.]

PHOTO. 6.
Workshops.

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PHOTO. 7.

Bank Builder.

PHOTO. 8. **Bucket Electric Dredger.**

PHOTO. 9.

Crane Tripods at the Headworks.

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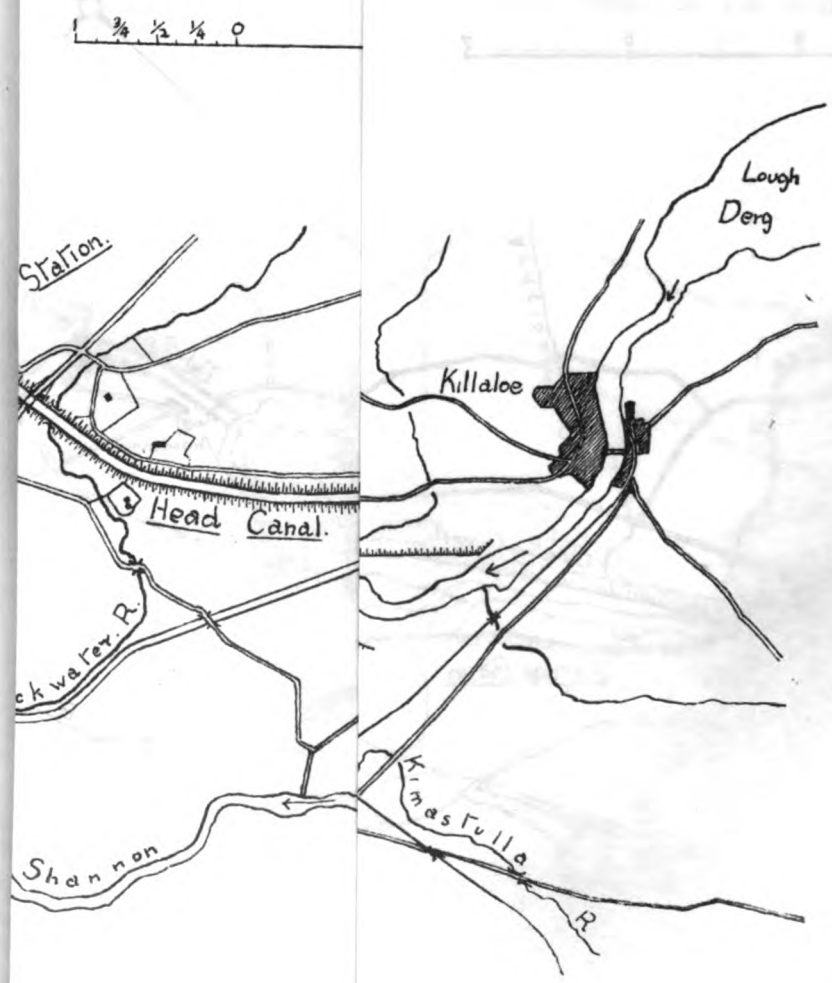
H SHOWING ME. Fig. 1.



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Irish labourers and one for 200 German specialists. The actual constructional details of these camps call for no special comment, but the very complete accommodation is worthy of note, including as it does, canteens, cook-houses, dining-rooms, bath-houses, and a separate mess for the engineering staff. The resident engineers are provided with wooden houses.

Temporary Power Station.—In order to supply electricity to the works, a power house has been erected to accommodate nine Diesel-driven alternators. The building consists of a steel skeleton, with concrete block walls and a slated wooden roof supported on steel purlins. Mention should be made of the very neat way in which principal rafters of heavy section are built up in one piece with the stanchions supporting the roof, thus obviating the use of roof trusses. The economy of the design over one using standard sections seems rather doubtful, unless a large number of similar buildings are being erected, but the elimination of tie-rods gives more headroom, and incidentally improves the appearance of the interior. The floor is of P.C. concrete and has the oil and water drains embedded in it, and the usual trench is provided for the exhaust pipework. The engine-room is well lighted and ventilated and there is ample gangway space.

Seven of the nine engines are by Krupp; each of these develops 520 H.P. at 214 R.P.M., and is coupled to an alternator of 320 K.V.A. rating. The remaining two sets, which are by Deutz, run at 250 R.P.M., and are rated at 270 H.P. and 160 K.V.A. All are of the vertical, totally enclosed, automatically lubricated type.

Though the contractors describe the engines as Diesels, no blast air is used. The Roumanian crude oil used as fuel is injected "solid" at a pressure of about 2,600 lbs. per sq. inch, a separate pump being provided for each cylinder. Fuel consumption is stated to be in the neighbourhood of the remarkably low figure of .375 lb. per B.H.P. hour.

The Krupp engines have the overhead cam-shaft which is usual in Diesel engines practice, but the valves of the Deutz engines are operated by push-rods from the crankcase, in the manner common in motor-car engineering, the design being neatly carried out. The exhaust gases are very effectually silenced by buried expansion boxes with baffles, and the whole plant runs smoothly and quietly.

The cooling water from the various jackets was originally run to waste, but as the whole supply has to be pumped, this was found to be uneconomical, and a cooling tower has since been erected to enable some of the water to be used again. The fuel oil for the engines is stored outside the buildings in five large cylindrical G.I. tanks, of 50 tons capacity each, sunk below ground-level and lying on their sides. From these the oil is pumped to the expense tanks in the engine room.

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On the electrical side, 50 cycle three-phase A.C. is generated at a pressure of 400 volts, and transformed up to 17,000 volts for transmission to distant parts of the works, where it is stepped down to 3,000 or 380 volts as required. The station switchgear, which is housed in a lean-to annexe at one side of the building, does not call for much comment, as it follows standard practice, the board being arranged in panels, and the H.T. gear having mechanical remote control. The transformer house, seen in Photo. 5, is provided with large double doors for each transformer, so that in the event of fire the offending unit can be quickly pushed out on to a small truck and removed to a distance. The truck and railway can be seen in the photograph.

The exceptionally unfavourable power factor of a load composed chiefly of lightly loaded induction motors is well illustrated at this station, where Cos ϕ falls as low as .45. The plant being temporary and of ample capacity, correction is presumably regarded as not worth while.

As would be expected, in view of the claim of 25% efficiency put forward for the installation, the cost of generation compares very favourably with that of the public supply station in Limerick, and negotiations are on foot for the sale of energy to the town, pending the completion of the hydro-electric station. Town lighting would be a good proposition, as the night load on the station is small at present, and the load factor could thus be improved.

Workshops.—These include :—

1. A composite repair shop for the maintenance of the large quantities of plant and machinery used on the works. This consists of a steel-framed building 275′ by 84′, with breeze block walls containing a smithy, a metal foundry, fitting, welding and machine shops and a tool-room. A 15-ton overhead electric crane of 50′ span runs right along one-half of the building. There are three locomotive pits under the gantry of this crane, the locomotives being run in on rails at right angles to the main axis of the building. The electrically-driven machinery installed includes lathes, planing, milling, grinding, multiple drilling, and hydraulic testing machines, and in the smiths' section a pneumatic power hammer and a shearing and punching machine. These shops employ 110 hands, and are capable of undertaking any ordinary repair, including the manufacture of spare parts if required. A view of the outside of the building is shown in Photo. 6.

2. A saw-mill, equipped with a log frame and circular saws, for the reduction of timber for temporary structures, railway sleepers, form-work, etc.

3. A carpenters' and joiners' shop, built in the same block with a wood-working machine shop, for the further treatment of timber which has been dealt with by the saw-mill. These shops are less

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used now that most of the temporary building and hutting has been completed.

4. A waggon building shop.

The machinery for all these shops is electrically driven from the temporary power station, the group system being extensively employed so as to reduce the number of motors needed.

Stores.—A stock of spares is held for the plant in use, and in the large general store, 138′ by 47′, is kept the supply of poles, wire, insulators, etc., required for the erection of transmission lines, and other stores for the building sites.

The cement is kept in a special store near the railway, to facilitate the off-loading of new supplies and the dispatch of the large quantities required on the works. Close to the store is a small laboratory, where the cement and the other ingredients of concrete are tested at frequent intervals to ensure the maintenance of the correct quality.

Coal Supply.—A large supply of coal is required, the daily consumption of the locomotives and steam-shovels amounting to about 40 tons. The coal arrives in steamers at Limerick harbour, where it is unloaded into motor lorries, which convey it to Longpavement station, where the terminus of the contractor's light railway is situated. This railway takes it on to Ardnacrusha, where it is deposited in the dump provided, which is capable of holding 1,000 tons. Distribution is effected by the works light railway.

Water Supply.—The necessary water supply is obtained from the Blackwater River, nearly a mile from the works, by means of an electrically-operated pumping plant, and is distributed from a water tower built on the high ground in the German camp.

IV. Plant and Machinery.

Excavating Machinery.—For excavating the most difficult soil, in which large boulders are liable to be met with, steam shovels are used. There is a total of 13 of these machines on the works, of which some are mounted on caterpillar tracks and some on railway wheels. They vary in capacity from 2 to ½ cubic metres.

For the easier work, electric bucket excavators are employed. Photos. 2, 3 and 7 show clearly the appearance of these excavators, the method of using them for bank-building, etc., and also how they are mounted on a double line of light railway. They have a capacity of 300 cubic metres per hour.

There are also 7 smaller caterpillar bucket excavators, which are used for the removal of top soil.

Light Railway System.—The works are served by an extensive 60 cm. railway system, which connects Longpavement station with Ardnacrusha and the headworks above O'Briensbridge. The main

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line from Longpavement will subsequently be relaid in 1.6 metre gauge as far as Ardnacrusha. (See Fig. 2).

For the running roads, flat bottomed rails spiked to wooden sleepers are used, but lines or sidings subject to frequent alterations are laid in Decauville track.

There are 58 locomotives, the majority of which are of the usual 0-4-0 type employed by contractors for this class of work, and have two outside cylinders with a modified form of Stephenson's link valve gear, operated by reverse cranks instead of by eccentrics. The rolling stock consists mainly of tip trucks for earth, of which there are 517 of various sorts, of from 3 to 5 cubic metres capacity.

Some electric locomotives have recently arrived from the continent, but have not yet been put into service.

Stone Crushing Plant.—This is situated at Ardnacrusha and is capable of dealing with about 10 cubic yards of the local compact sandstone per minute. The crushed stone is required on the works for concrete, railroad ballast, and road metal, and will be needed at a later stage for the stone rubble lining of the canals.

The raw stone is delivered to the plant in trucks, which are drawn up a ramp by an electric winch, situated on the side of the crusher house distant from the ramp. The machinery, which is by the International Baumaschinen Gesellschaft, consists of, first, a large crusher, with jaws 3 feet wide. After going through this, the stone is conveyed to a rattler, and thence to three smaller crushers, which reduce it still further. The crushed stone is then passed on to two inclined rotary graders and washers, finally falling into hoppers, whence it can be dropped directly into either lorries or railway trucks as desired. (See diagramatic Cross Sections, Fig. 3).

The water for washing is introduced into the upper end of the grader cylinders, up which the stone is raised by Archimedes' screws.

Cable Cranes.—These are in use at the headworks and at the power station site. The position and range of movement of the crane at Ardnacrusha is shown on the plan of the works (Fig. 2) ; it consists essentially of two lattice steel tripods, connected at the top by a suspension cable, along which a traveller carrying the electrically operated hoisting gear can be moved by means of a separate cable, the whole apparatus being operated from a cabin halfway up one of the supports.

The adaptability of this type of crane to almost any site, and its great utility for the rapid and precise handling of heavy loads, are self-evident. In calm weather, the accuracy of movement attainable is almost that of an ordinary crane, but it would be interesting to see the effect of a high wind when working over a long span.

Photo. 9 shows the tripods of the crane at the headworks ; it will be noted that the erection is not yet complete.

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V. Administrative Arrangements.

1. *Hours of Work.*—A fifty-hour week is worked by the 1,500 men employed, and at their own request, Saturday and Sunday are whole holidays, except for such routine work as pumping. The remaining five days of the week are ten hour days. The engineers approve highly of the arrangement, as they say that the men get through very little work on a Saturday morning when the more usual system of hours is followed.

2. *Camp Organisation and Discipline.*—The organisation and discipline of the workman's camps is on almost military lines, though of course rather free and easy, especially on Saturday evenings, when Wild West scenes are not infrequently enacted, the majority of the Irish having at least "drink taken."

Each camp is governed by a Camp Commandant, elected by the men themselves, but not dismissed by them. His word is law in the Camp, and to maintain order he appoints camp policemen, who take instructions from him only. He is empowered to award punishments and fines.

The men are housed on the barrack room principle, the rooms, &c., being inspected periodically by the Camp Commandant. All the engineers are also empowered to inspect and report on rooms, the occupants of any found dirty or untidy being sent before the Commandant. Proper attention to cleanliness and sanitation is thus assured.

3. *Messing, &c.*—Messing is arranged for by a Central Mess and Canteen. Each man pays a fixed sum (*i.e.*, 2s. 1d. per day) weekly for his meals, and for this he is fed amply and well, the standard being as high as that of the best messing in the Army. A varied diet is provided, but the main item in the Irish menu is potatoes, of which huge quantities are eaten, each man having as many as six or eight with his dinner. All meals are prepared by a permanent staff in a central cookhouse, provided with one large range and four boilers. The range is 12′ long, 5′ wide, and 3′ 6″ high, and has one central fire and flue; being centrally situated in the cookhouse, it is very convenient to use. The whole top gets hot and is available for pots, frying pans, etc., while the lower part contains ovens.

The Irish mess room, which adjoins the cookhouse, consists of a large hut 100′ by 50′. Arrangements are made for using it as a chapel on Sundays, and as a cinema at other times. A separate mess room is provided for the engineers, for though the majority of these live out, they have their mid-day meal at the works.

The Germans have a separate mess in their own camp, where Teutonic tastes are specially catered for, and shops are provided where *delicatessen* may be purchased. No intercourse is allowed between the two camps for fear of international disputes arising.

Both camps are lighted electrically from the temporary power

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station, and every effort is made to make the inhabitants comfortable. Entertainments are also provided, as the nearest town is Limerick which is several miles off.

VI. CONCLUDING REMARKS.

In the foregoing brief notes an attempt has been made to give an outline of the works on the Shannon from the technical point of view. The commercial and other benefits conferred on the country by the scheme must largely depend upon educating the population to use electricity. Provided that the station is adequately protected from the attacks of disaffected persons, the existing electricity undertakings in the Free State would be ready, or could be compelled by statute, to buy energy in bulk, and would thus constitute a paying load for the partial development. The linking up of the country districts will provide an additional source of revenue, but if the full benefit is to be derived, the complete utilisation of the power available is essential, and this will only be attained by vigorous propaganda. When it is remembered that large towns are few in the Free State, and that the majority of the people are accustomed to live, apparently contented, in conditions of discomfort and squalor unapproached in any part of England with which the writer is acquainted, the difficulty of pushing the sale of energy at once becomes apparent. Enough apathy and suspicion are met with in districts where the convenience and cleanliness of electricity make a stronger appeal than they do among the Irish.

Judging by the appreciations of the scheme published from time to time in the newspapers, the myth that hydro-electricity is power for nothing has not yet been exploded. The very heavy fixed charges on such undertakings are apparently forgotten, and the fact that running costs are small is over-emphasised. The fundamental economics of the question are allowed to be obscured by the fact that the scheme is financed by the Government from state revenue—as though the undertaking, if not a commercial success, would be less of an incubus by being a public liability. The notorious financial difficulties of the L.C.C. tramways afford an excellent illustration of this fallacy.

The idea that cheap power means flourishing industries is also very prevalent, and this in face of the fact that some of the districts in Great Britain where industrial depression is most acute are furnished with the cheapest supply of power, *e.g.*, the Clyde. In actual fact, no substitute has yet been found for active markets and a cheap source of raw materials, and power costs are, as a rule, but a small fraction of the whole cost of production. In short, the promotors of the scheme cannot view the future with confidence unmixed with anxiety, since the population is being told to expect an Eldorado which will not improbably fail to materialise.

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A RECENT DEVELOPMENT IN MECHANIZATION.

By MAJOR G. LE Q. MARTEL, D.S.O., M.C. R.E.

LONG before the Great War it was realised that as our regular army is so small and as our commitments all over the world are considerable, we should take advantage of the fact that we are one of the few highly trained regular armies in existence and develop our mobility and power of offence to the utmost to compensate for our inferiority in numbers. The same idea prevailed after the war and special attention was paid to mechanization for this reason. We started with the provision of one tank battalion per division but, with the reduced strength of the peace time army, this meant a very small number of tanks, and as the artillery had also to be very largely reduced, the Infantry were not much better off than in 1914 as regards attacking a defensive position. In connection with what may be called administrative mechanization we made great progress. Certain artillery brigades have been mechanized, giving them greatly increased mobility, and much has been done towards mechanizing army transport generally. In addition to increasing mobility, these changes have produced certain financial savings in maintenance and a reduction in tonnage necessary in sea transport, owing to the replacement of fodder by petrol and oil. This work however gives no direct tactical assistance to the infantryman; the tactical basis in battle is still the infantryman and he is only assisted on the battlefield by the very small number of tanks that we can afford in peace time.

It was with the above points in mind that I started, in January, 1925, to evolve a small cheap tank, which was to be made mainly of commercial motor components. There would then be a chance of having very much larger numbers of tanks in peace time and the possibility of expanding these numbers rapidly in the event of war. A further point which influenced me was that the existing types of tanks were being seriously threatened by anti-tank guns, and just as infantry had had to use dispersion to avoid casualties from machine guns, in the same way it seemed reasonable to suppose that, at any rate, a proportion of the large expensive tanks would have to "disperse" into a larger number of small tanks to avoid casualties from anti-tank weapons.

The first model of this tank was constructed from second-hand motor components to avoid expense, and many demonstrations were

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given in August and September, 1925. These demonstrations raised considerable interest and it was decided to order two of these tanks. I had in the meantime shewn the model to the managing director of Morris Commercial Cars and later he agreed to accept the order for the first two tanks to be made mainly of standard Morris components. The first experimental model had been a one-man tank and no difficulty was experienced in firing an automatic rifle while driving the tank at the same time. My object in keeping to a one-man tank was that a greater number (at least 50 per cent. greater) of one-man tanks could be constructed, manned and maintained for a given sum of money compared with two-man tanks; the difference being due to the cost of training and upkeep of the second man. There was however no difficulty in providing room for a second man in the tank and this did not materially affect the cost or performance of the tank. Of the first two Morris tanks to be ordered, one was a one-man and the other a two-man tank. Opinion is now strongly in favour of two men and the remainder of this article will refer to two-man tanks except where otherwise stated.

The main points in the mechanical design of the Morris tank were as follows:—

The engine was the 16 h.p. Morris Commercial engine, driving through a gear box with an emergency low speed on to a commercial type differential back axle, and sprockets at the ends of the axle to drive the tracks. So far, we have a very small compact Morris 1-ton van with tracks each side instead of wheels. A very small track machine of this nature would however be very bumpy on rough ground and the trench crossing capacity would be small; in addition, there would be a danger of the tank overturning backwards when rushing up a very steep bank. To obviate these difficulties a tail was added, carrying a pair of wheels which followed in rear of the tracks. A single wheel in rear would have had advantages, but by using a pair of wheels it was possible to employ a standard front axle and no special parts had to be manufactured. This afterwards proved to be a mistake and a single wheel should have been employed. These wheels could be controlled from the tank and they served to steer the machine; in addition they steadied the tank considerably over rough ground and they served as a precaution against overturning backwards. The body was in the normal position behind the bonnet and in the two-man tank it was wider and accommodated two men side by side. The body and all vital parts were armoured. In addition to the tail, another novelty was introduced in the body; the seats were made so that they could slide up and down very quickly and the top of the cab was left open. Normally, when not in close contact with the enemy, the men sit with their heads above the armour, so that they can see all round and be controlled by signals or word of mouth. When coming under

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fire, the men lower their seats and fight through a loophole in the armour plate. A movable top made of light armour would be necessary in mountainous districts and might be an advantage under all conditions.

Shortly after the appearance of my first experimental model another type, known as the Carden Lloyd, was produced. This was an unarmoured one-man tank and the whole machine was very small, low and inconspicuous: the idea was that the men should be carried very rapidly forward, and by speed and inconspicuousness they should be able to avoid casualties. These ideas were soon found to be impracticable and after the appearance of the Morris Tank, the Carden Lloyd was reconstructed to serve a similar purpose with an armoured body. The tank had a short track and no tail and possessed the disadvantages already referred to of a short track machine without a tail.

The Carden Lloyd tank was rapidly developed by Carden who was both the designer and the manufacturer, and successive models were produced. A single wheel tail was added, and a very clever system of wheel-cum-track transmission was introduced, so that the tank could carry out a long approach march on wheels and so save the wear and tear on the tracks. It will thus be seen that the two types are becoming similar; but they are both still comparatively undeveloped and many mechanical troubles will appear during the field tests. Whether the tank in its final form is more like the Carden or the Morris is a matter of no importance. What does matter is the fact that as a result of this work a tank could now be developed which would fill the following specification:—

Crew: Two men.
Armament: One machine gun.
Armour: Proof against S.A.A. at any range.
Speed: 30 Miles an hour on roads.
15 Miles an hour on tracks.
Transmission; Wheels for approach march, tracks in action.
Circuit of action: 100 Miles.
Weight: About two tons.

The tank to be capable of climbing very steep banks and cross any natural road ditches and a clear span 4 feet wide. The tank to be narrow and easy to handle, so that it can pass along narrow tracks and negotiate woods by passing between the trees. The cost in production should not exceed £500.

The tank to be reliable and cheap to maintain and the maintenance, including a proportion of the capital cost, not to exceed the annual cost of two infantrymen, i.e., one of these tanks with the crew of

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two men to be provided and maintained at the same cost as four infantrymen.

Having arrived at the type of tank that can be constructed from a mechanical point of view, we can now consider the tactical side. To do so it is first necessary to produce a picture of what the position might be in 10 or 15 years if we constructed large numbers of these small tanks. The picture will no doubt be very inaccurate—pictures of the future always turn out to be wrong in many ways—but unless we form a picture of some sort, we have nothing to aim at and the tactical trials stray in every direction. The picture that we will take is that of the whole of the infantry of the regular army being mounted like cavalry, but on bullet-proof horses (small tanks). Thus a battalion of infantry will become 500 men mounted in 250 small tanks. It is not suggested that 250 tanks would necessarily form the best tactical unit, but the figures can be used to compare the type of army that can be obtained for the same cost as the army in its present form. Thus the infantry would become mechanical infantry and they would be supported by artillery in much the same way as ordinary infantry, and under suitable circumstances they would be backed up by larger tanks. The mechanical infantry would be the tactical basis; they would set the pace on the march and in battle and all other arms would be required to assist them in every possible way. We will now try to see how an army of this nature could fill the requirements demanded of the British regular army.

Let us for a start take a typical case abroad, and assume that one infantry battalion is charged with the duty of the protection of the island of Singapore from invasion. The perimeter of the island is too long to establish anything in the nature of a linear defence, and the battalion would have to remain concentrated in one or two places. If the enemy effected a landing, the battalion, or a portion of the battalion, would at once be sent to attack the landing party and drive them back to the sea. With infantry it would be several hours before they could reach the place where the enemy had landed, and they would then probably encounter machine guns, which would cause further delays, and by that time the situation would be critical. If we change the infantry battalion into mechanical infantry, i.e. 500 men in 250 small tanks, the position is very different. They would be on the site in half an hour or less and could attack the enemy landing party at once, regardless of a defensive screen of machine guns, and the fear of an attack of this nature would do much to reduce the risk of the enemy attempting a landing at all. It is not suggested for a moment that no infantry would be wanted for the defence of the island; for instance, there would be many places, such as oil fuel depots, where a permanent infantry defence in trenches or block-houses would be essential. This type of work can however be

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quite well carried out by local volunteers. The expensive and highly trained regular soldiers should be kept as far as possible for offensive operations which need years of experience and practice and it is for this work that the small tanks would prove so useful.

Much the same arguments apply to most foreign stations. In countries like Egypt a larger proportion of armoured cars would no doubt be necessary. It is in India however that the greatest difficulties are met. A proportion of the British battalions in India are used on the North-West Frontier, where tanks are of little use. Under these circumstances, the mechanical infantry would have to dismount and fight on foot. This would not however offer an insuperable difficulty. Cavalry are trained to fight mounted and dismounted and well trained mechanical infantry would soon pick up the mountain warfare methods of the North-West Frontier. There is also the question of police work, which is important in India and, as the mechanical infantry would only possess half the numbers of men compared with existing battalions, police work would be more difficult. It is not however unreasonable to suppose that if half the existing garrison cannot keep order by the police work on foot, then the position is serious enough to call out the troops and for this purpose men in tanks would have every advantage over infantry.

Turning now to the question of a European war, the advantages of mechanical infantry appear to be very marked. The employment of a British Expeditionary Force of four divisions is not a very serious factor in the early phases of a Great War, but if we change this to mechanical force based on mechanical infantry we get a very different picture. The organization of the force would be very simple. The R.A.F. and armoured cars would carry out long distance reconnaissance. The mechanical infantry would carry out their own close reconnaissance and lead the assault, assisted by aeroplanes. In an attack against a defensive position they would be supported by heavier tanks and a full complement of mechanised artillery. The Royal Engineers would have as their main duty the construction of bridges and provision of communications for the force and the destruction of enemy communications. We would thus have a simple organization compared to the complex army which we possess at present, and the whole force could move 100 miles in 24 hours and exist for several days without communications. Such a force would be a tremendous threat to a large continental army. By moving rapidly round a flank and carrying out extensive demolitions behind the enemy, the latter would be rendered immobile without being attacked at all. It might be assumed that large continental armies would follow suit and adopt a similar type of army, but this would place them in a very difficult position. With conscript armies the men are practically unpaid and very

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large reductions in numbers would be necessary to provide funds wherewith to buy large numbers of tanks. Hence the change would be from a large conscript army to a small mechanical striking force. Now France and Germany are mainly concerned with the defence of a frontier 300 miles long, and even if the military advisers were agreed, it would be some time before the civilians would be satisfied with a small mechanical striking force instead of a large conscript army, for the defence of their frontier. As we have no continental frontier to defend, our position is quite different and we should make full use ofthis by having an army which is pre-eminently suitable as a striking force.

The above statements are an attempt to visualize a possible picture which might exist in the near future. An obvious criticism is that the whole of the infantry have been mechanised. This however is not quite a correct statement. Infantry will naturally be needed in battles of the future, but their work may be of a much simpler and easier nature than it is to-day. The above proposals suggested mechanizing the whole of the regular infantry, and this gives us such striking advantages that we may well be able to depend on volunteers, territorials or hastily raised troops for the policing and passive defence which would become the role of the infantry under these circumstances. The change from infantry to mechanical infantry would of course have to come slowly. Certain units at home and abroad would have to be mechanised first and these would relieve each other to provide the foreign service tours. These and many other difficulties would have to be faced, and certain weak points would have to be accepted, because no change to produce advantages can ever be introduced without facing certain disadvantages. The possible advantages however appear to far outweigh the disadvantages.

Finally, if we believe in some picture of this nature as a possibility in the near future, we should take certain steps now to lead us in this direction, and the following appear to be the four most important. Firstly we must concentrate on the design of the tank that we require. There is no reason why this tank should not become as reliable and fool-proof as the motor car of to-day, but it will require a concentrated effort for a couple of years on the part of the technical branches concerned to achieve this result. Secondly, we need an experimental unit equipped with these tanks, for tactical trials and to demonstrate what they can and cannot do. Thirdly, we shall need a travelling committee of officers who know exactly what this unit can do, to visit foreign stations and see how and where the mechanical infantry can meet our commitments. And lastly, if we are to become a first class mechanical power, we will need a first-class technical organization to design, produce, inspect and repair the great fleet of mechanical vehicles which will be required for the army.

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BATTLE HONOURS OF ROYAL ENGINEER UNITS (continued).

AMIENS, 8TH-11TH AUGUST, 1918.

Unit.	Formation.		Remarks.
FOURTH ARMY.			
ARMY TROOPS.			
D. Special (Cylinder) Co.	III Corps	N.E.	
H. ,,	III ,,	E.	
7. ,,	III ,,	,,	
No. 1 Special (Mortar) Co.	III ,,	,,	
No. 2 ,,	Can. ,,	,,	
648th (H.C.) Field Co.	Aust. ,,	N.E.	No diary.
144th Army Troops Co.	Can. ,,	,,	
146th ,,	Cavy.,,	E.	
213th ,,	4th Army	N.E.	
216th ,,	Aust. Corps	,,	Arrived in area 11th Aug.
221st ,,	III Corps	,,	
238th ,,	Aust. ,,	E.	
283rd ,,	III ,,	,,	
288th ,,	III ,,	N.E.	
567th ,,	Aust. ,,	E.	
574th ,,	Aust. ,,	N.E.	No diary.
1st Aust. ,,	Anst. ,,	E.	
No. 1 Siege Co. R. Anglesey	III ,,	,,	
No. 4 ,,	Can. ,,	,,	
180th Tunnelling Co.	III ,,	D.	
182nd ,,	Can. ,,	E.	
253rd ,,	III ,,	,,	
254th ,,	4th Army	N.E.	
256th ,,	III Corps	E.	
1st Aust. ,,	Aust. ,,	,,	
2nd Aust. ,,	Aust. ,,	,,	
No. 6 Foreway Co.	III & Can. Corps	N.E.	
1st Tramways Co. C.E.	Can. Corps	,,	
CAVALRY CORPS.			
1st Field, Sqn.	1st Cavy. Div.	E.	
2nd ,,	2nd ,,	,,	
3rd	3rd ,,	,,	
III CORPS.			
69th Field Co.	12th Div.	,,	
70th ,,	,,	,,	
87th ,,	,,	,,	
79th ,,	18th Div.	,,	
80th ,,	,,	,,	
92nd ,,	,,	,,	
517th Field Co.	47th Div.	N.E.	
518th ,,	,,	D.	Within area on 11th Aug., but not employed.
520th ,,	,,	,,	Within area on 11th Aug., but not employed.
503rd ,,	58th Div.	E.	
504th ,,	,,	,,	
511th ,,	,,	,,	

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AMIENS, 8TH-11TH AUGUST, 1918.

Unit	Formation.		Remarks.
CANADIAN CORPS.			
206th Field Co.	32nd Div.	E.	
218th ,,	,,	,,	
219th ,,	,,	,,	
1st Bn. Can. Eng.	1st Can. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
1st P.B.T. Unit	,,	,,	
4th Bn. C.E.	2nd Can. Div.	,,	
5th ,,	,,	,,	
6th ,,	,,	,,	
2nd P.B.T. Unit.	,,	,,	
7th Bn. C.E.	3rd Can. Div.	,,	
8th ,,	,,	,,	
9th ,,	,,	,,	
3rd P.B.T. Unit	,,	,,	
10th Bn. C.E.	4th Can. Div.	,,	
11th ,,	,,	,,	
12th ,,	,,	,,	
4th P.B.T. Unit	,,	,,	
AUSTRALIAN CORPS.			
77th Field Co.	17th Div.	D.	Within area, but not employed.
78th ,,	,,	,,	
93rd ,,	,,	,,	
1st Aust. Field Co.	1st Aust. Div.	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
5th ,,	2nd Aust. Div.	,,	
6th ,,	,,	,,	
7th ,,	,,	,,	
9th ,,	3rd Aust. Div.	,,	
10th ,,	,,	,,	
11th ,,	,,	,,	
4th ,,	4th Aust. Div.	,,	
12th ,,	,,	,,	
13th ,,	,,	,,	
8th ,,	5th Aust. Div.	,,	
14th ,,	,,	,,	
15th ,,	,,	,,	

SIGNALS.

AMIENS, 8TH-11TH AUGUST, 1918.

Unit.	Formation.		Remarks.
Fourth Army Signal Co.		D	
Cavy. Corps Signal Co.	Cav. Corps	E.	
1st Signal Sqn.	1st Cav. Div.	,,	
2nd ,,	2nd ,,	,,	
3rd ,,	3rd ,,	,,	
C. Corps Signal Co.	III Corps	D.	
12th Divl. Signal Co.	,,	E.	
18th ,,	,,	,,	
47th ,,	,,	N.E.	
58th ,,	,,	E.	
Can. Corps Signal Co.	Can. Corps	,,	
32nd Divl. Signal Co.	,,	,,	
1st Can. ,,	,,	,,	
2nd Can. ,,	,,	,,	
3rd Can. ,,	,,	,,	
4th Can. ,,	,,	,,	

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SIGNALS.

AMIENS, 8TH-11TH AUGUST, 1918.

Units.	Formation.	Remarks.
Aust. Corps Signal Co.	Aust. Corps.	D.
17th Divl. Signal Co.	,,	E.
1st Aust. ,,	,,	,,
2nd Aust. ,,	,,	,,
3rd Aust. ,,	,,	,,
4th Aust. ,,	,,	,,
5th Aust. ,,	,,	,,

N.B.—"SOMME, 1918," COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN THE BATTLES OF ALBERT, 1918, AND BAPAUME, 1918.

ALBERT, 1918, 21ST-23RD AUGUST, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
"J" Special (Cylinder) Co.	VI Corps	N.E.	
"K" ,,	IV ,,	,,	
"N" ,,	V ,,	E	
"Q" ,,	IV ,,	N.E.	
No. 3 Special (Mortar) Co.	IV ,,	,,	
546th Field Co. (73rd Div.)	VI ,,	,,	
547th ,, ,,	VI ,,	,,	
132nd Army Troops Co.	VI ,,	,,	
142nd ,,	IV ,,	,,	
147th ,,	V ,,	E.	
149th ,,	IV ,,	,,	
232nd ,,	VI ,,	,,	
280th ,,	V ,,	,,	
559th ,,	V ,,	,,	
565th ,,	VI ,,	,,	
577th ,,		N.E.	
7th R. Mon. Troops Co.	IV ,,	E.	
No. 2 Siege Co. R. Anglesey	VI ,,	N.E.	
174th Tunnelling Co.	VI ,,	E.	
175th ,,	V ,,	,,	**With 21st Div. No diary.**
177th ,,	VI ,,	,,	
178th ,,	V ,,	,,	**With 38th Div.**
179th ,,	IV ,,	,,	
181st ,,	VI ,,	N.E.	
183rd ,,	V ,,	E.	
252nd ,,	IV ,,	,,	
258th ,,	3rd Army	N.E.	
N.Z. ,,	IV Corps	E.	
No. 3 Pontoon Park	V & VI Corps	D.	
No. 1 Foreway Co.		N.E.	
No. 8 ,,		,,	**No diary.**
IV CORPS.			
59th Field Co.	5th Div.	E.	
491st ,,	,,	,,	
527th ,,	,,	,,	
152nd ,,	37th Div.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	
427th ,,	42nd Div.	,,	
428th ,,	,,	,,	
429th ,,	,,	,,	
247th ,,	63rd Div.	,,	
248th ,,	,,	,,	
249th ,,	,,	,,	
1st N.Z. Field Co.	N.Z. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	

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ALBERT, 1918, 21ST-23RD AUGUST, 1918.

Unit.	Formation.		Remarks.
V CORPS.			
77th Field Co.	17th Div.	D.	Within area, but not employed.
78th ,,	,,	,,	
93rd ,,	,,	N.E.	
97th ,,	21st Div.	E.	
98th ,,	,,	,,	
126th ,,	,,	,,	
123rd ,,	38th Div.	,,	
124th ,,	,,	,,	
151st ,,	,,	,,	
VI CORPS.			
55th Field Co.	Guards Div.	,,	
75th ,,	,,	,,	
76th ,,	,,	,,	
5th ,,	2nd Div.	,,	
226th ,,	,,	,,	
483rd ,,	,,	,,	
56th ,,	3rd Div.	,,	
438th ,,	,,	,,	
529th ,,	,,	,,	
410th ,,	52nd Div.	N.E.	
412th ,,	,,	E.	
413th ,,	,,	N.E.	
416th ,,	56th Div.	E.	
512th ,,	,,	,,	
513th ,,	,,	N.E.	
467th ,,	59th Div.	E.	
469th ,,	,,	,,	
470th ,,	,,	,,	
FOURTH ARMY.			
ARMY TROOPS.			
"D" Special (Cyl) Co.	III Corps	E.	
"Z" ,,	Aust. ,,	N.E.	
No. 1 Special (Mortar) Co.	III ,,	E.	
648th (H.C.) Field Co.	Aust. ,,	N.E.	No diary.
144th Army Troops Co.	III ,,	E.	
146th ,,	Aust. ,,	,,	
213th ,,	4th Army	N.E.	
216th ,,	Aust. Corps	E.	
221st ,,	III ,,	N.E.	
238th ,,	Aust. ,,	D.	
283rd ,,	III ,,	E.	
288th ,,	III ,,	N.E.	
567th ,,	Aust. ,,	,,	
574th ,,	Aust. ,,	,,	No diary.
1st Aust. Troops Co.	Aust. ,,	E.	
No. 1 Siege Co. R. Anglesey	III ,,	,,	
No. 4 ,,	III ,,	,,	
180th Tunnelling Co.	III ,,	D.	
182nd ,,	III ,,	E.	
253rd ,,	III ,,	,,	
254th ,,	Aust. ,,	D.	
256th ,,	III ,,	E.	
1st Aust. Tunnelling Co.	Aust. ,,	D.	
2nd Aust ,,	Aust. ,,	,,	
No. 6 Foreway Co.		N.E.	
III CORPS.			
69th Field Co.	12th Div.	E.	
70th ,,	,,	,,	
87th ,,	,,	,,	

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ALBERT, 1918, 21ST-23RD AUGUST, 1918.

Unit.	Formationii		Remarks.
79th Field Co.	18th Div.	E.	
80th ,,	,,	,,	
92nd ,,	,,	,,	
517th ,,	47th Div.	,,	
518th ,,	,,	,,	
520th ,,	,,	,,	
503rd ,,	58th Div.	N.E.	
504th ,,	,,	,,	
511th ,,	,,	,,	
AUSTRALIAN CORPS.			
206th Field Co.	32nd Div.	E.	
218th ,,	,,	,,	
219th ,,	,,	,,	
1st Aust. Field Co.	1st Aust. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
9th ,,	3rd Aust. Div.	,,	
10th ,,	,,	,,	
11th ,,	,,	,,	
4th ,,	4th Aust. Div.	N.E.	
12th ,,	,,	,,	
13th ,,	,,	,,	
8th ,,	5th Aust. Div.	D.	Within area, but not employed.
14th ,,	,,	E.	
15th ,,	,,	D.	Within area, but not employed.

SIGNALS.

ALBERT, 1918, 21ST-23RD AUGUST, 1918.

Unit.	Formation.		Remarks.
Third Army Signal Co.		N.E.	
"D" Corps Signal Co.	IV Corps	D.	
5th Divl. Signal Co.	IV ,,	E.	
37th ,,	IV ,,	,,	
42nd ,,	IV ,,	,,	
63rd ,,	IV ,,	,,	
N.Z. ,,	IV ,,	,,	
"O" Corps Signal Co.	V ,,	D.	
17th Divl. Signal Co.	,,	,,	
21st ,,	V ,,	E.	
38th ,,	,,	,,	
"F" Corps Signal Co.	VI ,,	D.	
Guards Divl. Signal Co.	VI ,,	E.	
2nd ,,	VI ,,	,,	
3rd ,,	VI ,,	,,	
52nd ,,	VI ,,	,,	
56th ,,	VI ,,	,,	
59th ,,	VI ,,	D.	
Fourth Army Signal Co.		N.E.	
"C" Corps Signal Co.	III ,,	D.	
12th Divl. Signal Co.	III ,,	E.	
18th ,,	III ,,	,,	
47th ,,	III ,,	,,	
58th ,,	III ,,	D.	
Aust. Corps Signal Co.	Aust. Corps.	,,	
32nd Divl. Signal Co.	Aust. ,,	E.	
1st Aust. ,,	Aust. ,,	,,	
3rd Aust. ,,	Aust. ,,	,,	
4th Aust. ,,	Aust. ,,	N.E.	
5th Aust. ,,	Aust. ,,	E.	

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BAPAUME, 1918, 31ST AUGUST-3RD SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
"J" Special (Cyl.) Co.	VI Corps	N.E.	
"K" ,,	IV ,,	,,	
"N" ,,	V ,,	,,	
"Q" ,,	IV ,,	,,	
No. 3 Special (Mortar) Co.	IV ,,	,,	
546th Field Co. (73rd Div.)	VI ,,	E.	
547th ,, ,,	V ,,	N.E.	
549th ,, ,,	VI ,,	E.	
132nd Army Troops Co.	VI ,,	D.	
142nd ,,	IV ,,	E.	
147th ,,	V ,,	N.E.	
149th ,,	IV ,,	,,	
232nd ,,	XVII Corps	,,	
280th ,,	V Corps	,,	
559th ,,	V ,,	D.	
565th ,,	VI ,,	E.	
577th ,,	IV ,,	N.E.	
7th R. Mon. Army Troops Co.	IV ,,	D.	
4th Siege Co. R.M.R.E.	VI ,,	,,	Employed under C.R.E. 73rd Div.
174th Tunnelling Co.	VI ,,	E.	
175th ,,	V ,,	D.	No diary.
178th ,,	V ,,	N.E.	
179th ,,	IV ,,	E.	
181st ,,	VI ,,	N.E.	
183rd ,,	V ,,	D.	
252nd ,,	IV ,,	E.	
258th ,,	3rd Army	,,	
N.Z. ,,	IV Corps	N.E.	
No. 1 Foreway Co.		D.	
No. 2 ,,		,,	
No. 8 ,,		,,	
IV CORPS.			
59th Field Co.	5th Div.	E.	
491st ,,	,,	,,	
527th ,,	,,	,,	
152nd ,,	37th Div.	,,	
153rd ,,	,,	,,	
154th ,,	,,	,,	
427th ,,	42nd Div.	,,	
428th ,,	,,	,,	
429th ,,	,,	,,	
1st N.Z. Field Co.	N.Z. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
V CORPS			
77th Field Co.	17th Div.	,,	
78th ,,	,,	N.E.	
93rd ,,	,,	E.	
97th ,,	21st Div.	,,	
98th ,,	,,	,,	
126th ,,	,,	,,	
123rd ,,	38th Div.	,,	
124th ,,	,,	,,	
151st ,,	,,	N.E.	
VI CORPS.			
55th Field Co.	Guards Div.	E.	
75th ,,	,,	D.	
76th ,,	,,	E.	

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BAPAUME, 1918, 31ST AUGUST-3RD SEPTEMBER, 1918.

Unit.	Formation.	Remarks.
5th Field Co.	2nd Div.	E.
226th ,,	,,	,,
483rd ,,	,,	,,
56th ,,	3rd Div.	D.
438th ,,	,,	E.
529th ,,	,,	,,
457th ,,	62nd Div.	,,
460th ,,	,,	,,
461st ,,	,,	,,
FOURTH ARMY.		
ARMY TROOPS.		
"D" Special (Cyl.) Co.	III Corps	N.E.
"Z" ,,	Aust. ,,	,,
No. 1 Special (Mortar) Co.	III ,,	,,
648th Field Co.	Aust. ,,	,,
144th Army Troops Co.	III ,,	D.
146th ,,	Aust. ,,	N.E.
213th ,,	4th Army	,,
210th ,,	Aust. Corps	E.
221st ,,	III ,,	N.E.
238th ,,	Aust. ,,	E.
283rd ,,	III ,,	N.E.
288th ,,	III ,,	E.
567th ,,	Aust. ,,	,,
574th ,,	Aust. ,,	N.E. No diary
1st Aust. Army Troops Co.	Aust. ,,	E.
No. 1 Siege Co. R.A. R.E.	III ,,	,,
No. 4 ,,	III ,,	,,
180th Tunnelling Co.	III ,,	,,
182nd ,,	III ,,	,,
253rd ,,	III ,,	,,
254th ,,	Aust. ,,	N.E.
256th ,,	III ,,	E.
1st Aust. Tunnelling Co.	Aust. ,,	,,
2nd Aust. ,,	Aust. ,,	,,
No. 6 Foreway Co.		NE..
III CORPS.		
69th Field Co.	12th Div.	N.E.
70th ,,	,,	D.
87th ,,	,,	N.E.
79th ,,	18th Div.	E.
80th ,,	,,	,,
92nd ,,	,,	,,
517th ,,	47th Div.	,,
518th ,,	,,	,,
520th ,,	,,	,,
503rd ,,	58th Div.	,,
504th ,,	,,	,,
511th ,,	,,	,,
No. 5 Field Co. R.A. R.E.	74th Div.	,,
No. 5 Field Co. R.M. R.E.	,,	,,
439th Field Co.	,,	,,
AUSTRALIAN CORPS.		
206th Field Co.	32nd Div.	,,
218th ,,	,,	,,
219th ,,	,,	,,
5th Aust. Field Co.	2nd Aust. Div.	,,
6th ,,	,,	,,
7th ,,	,,	,,
9th ,,	3rd Aust. Div.	,,
10th ,,	,,	,,
11th ,,	,,	,,

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BAPAUME, 1918, 31ST AUGUST-3RD SEPTEMBER, 1918.

Unit.	Formation.	Remarks.
8th ,,	5th Aust. Div. ,,	
14th ,,	,, ,,	
15th ,,	,, ,,	

SIGNALS.

BAPAUME, 1918, 31ST AUGUST-3RD SEPTEMBER, 1918.

Unit.	Formation.	Remarks.
Third Army Signal Co.		N.E.
"D" Corps Signal Co.	IV Corps	D.
5th Divl. Signal Co.	,,	E.
37th ,,	,,	,,
42nd ,,	,,	,,
N.Z. ,,	,,	,,
"O" Corps Signal Co.	V Corps	D.
17th Divl. Signal Co.	,,	E.
21st ,,	,,	,,
38th ,,	,,	,,
"F" Corps Signal Co.	VI Corps	D.
Guards Divl. Signal Co.	,,	E.
2nd ,,	,,	,,
3rd ,,	,,	,,
62nd ,,	,,	,,
Fourth Army Signal Co.		N.E.
"C" Corps Signal Co.	III Corps	D.
12th Divl. Signal Co.	,,	,,
18th ,,	,,	E.
47th ,,	,,	,,
58th ,,	,,	,,
74th ,,	,,	,,
Aust. Corps Signal Co.	Aust. Corps	D.
32nd Divl. Signal Co.	,,	E.
2nd Aust. ,,	,,	,,
3rd Aust. ,,	,,	,,
5th Aust. ,,	,,	,,

N.B. "ARRAS, 1918," COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN THE BATTLES SCARPE, 1918, AND DROCOURT-QUEANT.

SCARPE, 1918. 26TH-30TH AUGUST, 1918.

Unit.	Formation.	Remarks.
FIRST ARMY.		
ARMY TROOPS.		
Special Cos.	First Army	N.E.
106th Field Co. (25th Div.)	XXII Corps	,,
25th Army Troops Co.	First Army	,,
217th ,,	XXII Corps	,,
230th ,,	First Army	,,
282nd ,,	VIII Corps	,,
290th ,,		,,
560th ,,		,,
568th ,,	XXII Corps	,,
1st Can. ,,	Can. Corps	,,
2nd Can ,,	,,	E.
3rd Can. ,,	,,	,,
4th Can. ,,	,,	,,
5th Can. ,,	,,	,,
1st Siege Co. R.M.R.E.	VIII Corps	N.E.

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SCARPE, 1918. 26TH-30TH AUGUST, 1918.

Unit.	Formaiton.		Remarks.
172nd Tunnelling Co.	VIII & XXII Corps	,,	
176th ,,		,,	
185th ,,	VIII Corps	,,	
1st Tramway Co. Can Eng.	Can. Corps	E.	
2nd ,,	,,	,,	
VIII CORPS.			
2nd Field Co.	8th Div.	E.	
15th ,,	,,	D.	
490th ,,	,,	N.E.	
XXII CORPS			
67th Field Co.	11th Div.	D.	Within area on 30th August "standing by."
68th ,,	,,	,,	
86th ,,	,,	,,	
400th ,,	51st Div.	E.	
401st ,,	,,	,,	
404th ,,	,,	,,	
CANADIAN CORPS.			
9th Field Co.	4th Div.	E.	
406th ,,	,,	,,	
526th ,,	,,	,,	
1st Bn. Can. Eng.	1st Can. Div.	,,	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
1st P.B.T. Unit	,,	,,	
4th Bn. C.E.	2nd Can. Div.	,,	
5th ,,	,,	,,	
6th ,,	,,	,,	
2nd P.B.T. Unit	,,	,,	
7th Bn. C.E.	3rd Can. Div.	,,	
8th ,,	,,	,,	
9th ,,	,,	,,	
3rd P.B.T.	,,	,,	
10th Bn. C.E.	4th Can. Div.	,,	
11th ,,	,,	,,	
12th ,,	,,	,,	
4th P.B.T. Unit	,,	N.E.	
THIRD ARMY.			
ARMY TROOPS.			
232nd Army Troops Co.	XVII Corps	E.	
No. 2 Siege Co. R.A. R.E.	,,	,,	
177th Tunnelling Co.	,,	,,	
XVII CORPS.			
410th Field Co.	52nd Div.	F.	
412th ,,	,,	,,	
413th ,,	,,	,,	
416th ,,	56th Div.	,,	
512th ,,	,,	,,	
513th ,,	,,	,,	
421st ,,	57th Div.	,,	
502nd ,,	,,	,,	
505th ,,	,,	,,	

SIGNALS.

SCARPE, 1918. 26TH-30TH AUGUST, 1918.

Unit.	Formation.	Remarks.
First Army Signal Co.		N.E.
S Corps Signal Co.	VIII Corps	,,
8th Div. Signal Co.	,,	D.

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SIGNALS.

SCARPE, 1918. 25TH-30TH AUGUST, 1918.

Unit.	Formation.	Remarks.
Y Corps Signal Co.	XXII Corps	N.E.
11th Div. Signal Co.	,,	E.
51st ,,	,,	,,
Can. Corps Signal Co.	Can. Corps	D.
4th Div. Signal Co.	,,	E.
1st Can. ,,	,,	,,
2nd Can. ,,	,,	,,
3rd Can. ,,	,,	,,
4th Can. ,,	,,	N.E.
Third Army Signal Co.		,,
R Corps Signal Co.	XVII Corps	D.
52nd Div. Signal Co.	,,	E.
56th ,,	,,	,,
57th ,,	,,	,,

DROCOURT-QUEANT. 2ND-3RD SEPTEMBER, 1918.

Unit.	Formation.	Remarks.
FIRST ARMY.		
ARMY TROOPS.		
106th Field Co. (25th Div.)	XXII Corps	N.E.
217th Army Troops Co.	XXII ,,	,,
568th ,,	XXII ,,	,,
1st Can. ,,	Can. ,,	,,
2nd Can. ,,	Can. ,,	,,
3rd Can. ,,	Can. ,,	,,
4th Can. ,,	Can. ,,	D.
5th Can. ,,	Can. ,,	N.E.
172nd Tunnelling Co.	XXII ,,	,,
179th ,,	XXII ,,	,,
1st Tramway Co. C.E.	Can. ,,	D.
2nd ,,	Can. ,,	,,
No. 7 Foreway Co.	XXII ,,	,, No diary.
XXII CORPS.		
67th Field Co.	11th Div.	E.
68th ,,	,,	N.E.
86th ,,	,,	E.
CANADIAN CORPS.		
23rd Field Co.	1st Div.	E.
26th ,,	,,	,,
409th ,,	,,	,,
9th Field Co.	4th Div.	,,
406th ,,	,,	,,
526th ,,	,,	,,
1st Bn. C.E. 1st Bde. C.E.	1st Can. Div.	,,
2nd ,,	,,	,,
3rd ,,	,,	,,
1st P.B.T. Unit	,,	,,
4th Bn. C.E. 2nd Bde. C.E.	2nd Can. Div.	,,
5th ,,	,,	,,
6th ,,	,,	D.
2nd P.B.T. Unit	,,	,,
7th Bn. C.E. 3rd Bde. C.E.	3rd Can. Div.	N.E.
8th ,,	,,	E
9th ,,	,,	,,
3rd P.B.T. Unit	,,	N.E.
10th Bn. C.E. 4th Bde. C.E.	4th Can. Div.	E.
11th ,,	,,	,,
12th ,,	,,	,,
4th P.B.T. Unit	,,	,,

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DROCOURT-QUEANT. 2ND-3RD SEPTEMBER, 1918.

Unit.	Formation.	Remarks.
THIRD ARMY.		
ARMY TROOPS.		
232nd Army Troops Co.	XVII Corps	D.
No. 2 Siege Co. R.A.R.E.	XVIII ,,	,,
177th Tunnelling Co.	XVIII ,,	E.
XVII CORPS.		
410th Field Co.	52nd Div.	E.
412th ,,	,,	,,
413th ,,	,,	,,
416th ,,	56th Div.	,,
512th ,,	,,	N.E.
513th ,,	,,	,,
421st ,,	57th Div.	E.
502nd ,,	,,	,,
505th ,,	,,	,,
247th ,,	63rd Div.	,,
248th ,,	,,	,,
249th ,,	,,	,,

SIGNALS.

DROCOURT-QUEANT. 2ND-3RD SEPTEMBER, 1918.

Unit.	Formation.	Remarks.
First Army Signal Co.		N.E.
Y Corps Signal Co.	XXII Corps	,,
11th Div. Signal Co.	,,	D.
Can. Corps Signal Co.	Can. Corps	N.E.
1st Div. Signal Co.	,,	E.
4th ,,	,,	,,
1st Can. ,,	,,	,,
4th Can. ,,	,,	,,
Third Army Signal Co.		N.E.
R Corps Signal Co.	XVII Corps	D.
52nd Div. Signal Co.	,,	E.
57th ,,	,,	,,
63rd ,,	,,	,,

N.B.—"HINDENBURG LINE" COUNTS AS AN EXTRA HONOUR FOR PARTICIPATION IN ANY OF THE BATTLES FROM HAVRINCOURT TO CAMBRAI, 1918.

HAVRINCOURT. 12TH SEPTEMBER, 1918.

Unit.	Formation.	Remarks.
THIRD ARMY.		
ARMY TROOPS.		
J Special (Cyl.) Co.	VI Corps	N.E.
K ,,	IV ,,	,,
N ,,	V ,,	,,
Q ,,	IV ,,	,,
No. 3 Special (Mortar) Co.	IV ,,	,,
546th Field Co. (73rd Div.)	VI ,,	,,
547th ,,	V ,,	,,
549th ,,	VI ,,	,,
132nd Army Troops Co.	VI ,,	,,
142nd ,,	IV ,,	D.
147th ,,	V ,,	N.E.
149th ,,	IV ,,	D.
280th ,,	V ,,	N.E.
559th ,,	V ,,	,,

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HAVRINCOURT. 12TH SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
565th "	VI "	E.	
577th "	IV "	N.E.	
7th R. Mon. "	IV "	"	
4th Siege Co. R.M. R.E.	V "	"	
174th Tunnelling Co.	VI "	D.	
175th "	V "	"	No diary.
178th "	V "	N.E.	
181st "	VI "	D.	
183rd "	V "	N.E.	
252nd "	IV "	D.	
258th "	Third Army	"	
N.Z. "	IV Corps	"	
No. 1 Foreway Co.		N.E.	
IV CORPS.			
152nd Field Co.	37th Div.	E.	
153rd "	"	N.E.	
154th "	"	E.	
1st N.Z. Field Co.	N.Z. Div.	N.E.	
2nd "	"	"	Within area but not employed.
3rd "	"	"	
V. CORPS.			
77th Field Co.	17th Div.	N.E.	
78th "	"	"	
93rd "	"	"	
97th "	21st Div.	"	
98th "	"	"	
126th "	"	"	
123rd "	38th Div.	"	
124th "	"	D.	
151st "	"	N.E.	
VI CORPS.			
55th Field Co.	Guards Div.	N.E.	
75th "	"	D.	
76th "	"	"	
5th "	2nd Div.	N.E.	
226th "	"	"	
483rd "	"	"	
457th "	62nd Div.	E.	
460th "	"	"	
461st "	"	"	

SIGNALS.

HAVRINCOURT. 12TH SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
Third Army Signal Co.		N.E.	
D Corps Signal Co.	IV Corps	"	
37th Div. Signal Co.	"	D.	
N.Z. "	"	"	
O Corps Signal Co.	V Corps	N.E.	
17th Div. Signal Co.	"	"	
38th "	"	D.	
F Corps Signal Co.	VI Corps	N.E.	
Guards Div. Signal Co.	"	"	
2nd "	"	"	
62nd "	"	E.	

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EPEHY. 18TH SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
THIRD ARMY.			
ARMY TROOPS.			
Special Co's.	Third Army	N.E.	
142nd Army Troops Co.	IV Corps	,,	
147th ,,	V ,,	E.	
149th ,,	IV ,,	N.E.	
280th ,,	V ,,	D.	
559th ,,	V ,,	E.	
577th ,,	IV ,,	N.E.	
7th R. Mon. ,,	IV ,,	,,	
4th Siege Co. R. Mon.	V ,,	E.	
175th Tunnelling Co.	V ,,	,,	
178th ,,	V ,,	N.E.	
183rd ,,	V ,,	E.	
252nd ,,	IV ,,	,,	
258th ,,	3rd Army	N.E.	
N.Z. ,,	IV Corps	,,	
IV CORPS.			
59th Field Co.	5th Div.	N.E.	
491st ,,	,,	D.	
527th ,,	,,	E.	
V CORPS.			
77th Field Co.	17th Div.	E.	
78th ,,	,,	,,	
93rd ,,	,,	D.	
97th ,,	21st Div.	E.	
98th ,,	,,	,,	
126th ,,	,,	,,	
11th ,,	33rd Div.	D.	Within area, but not employed.
212th ,,	,,	N.E.	
222nd ,,	,,	,,	
123rd ,,	38th Div.	E.	
124th ,,	,,	D.	"Standing to" just outside area.
151st ,,	,,	,,	"Standing to" just outside area.
FOURTH ARMY.			
ARMY TTOOPS.			
Special Cos.	4th Army	N.E.	
648th (H.C.) Field Co.	Aust. Corps	,,	
144th Army Troops Co.	III ,,	E.	
146th ,,	Aust. ,,	N.E.	
213th ,,	4th Army	,,	
216th ,,	IX Corps	,,	
221st ,,	IX ,,	,,	
238th ,,	Aust. ,,	D.	
283rd ,,	III ,,	,,	
288th ,,	III ,,	,,	
567th ,,	IX ,,	N.E.	
574th ,,	Aust. ,,	,,	
1st Siege Co., R.A.R.E.	III ,,	D.	
4th ,,	IX ,,	,,	
224th Transportation Works Co. R.E.	III ,,	,,	
1st Aust. Army Troops Co.	Aust. ,,	E.	
180th Tunnelling Co.	III ,,	E.	
182nd ,,	III ,,	,,	
253rd ,,	IX ,,	N.E.	
254th ,,	IX ,,	,,	
256th ,,	III ,,	,,	
1st Aust. ,,	Aust. ,,	D.	
2nd ,,	Aust. ,,	,,	

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EPEHY. 18TH SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
III CORPS.			
69th Field Co.	12th Div.	E.	
70th ,,	,,	,,	
87th ,,	,,	,,	
79th ,,	18th Div.	,,	
80th ,,	,,	,,	
92nd ,,	,,	,,	
503rd ,,	58th Div.	,,	
504th ,,	,,	,,	
511th ,,	,,	,,	
5th Field Co. R.A.R.E.	74th Div.	,,	
5th Field Co. R.M.R.E.	,,	,,	
439th ,,	,,	,,	
IX CORPS.			
23rd Field Co.	1st Div.	E.	
26th ,,	,,	,,	
469th ,,	,,	,,	
12th ,,	6th Div.	,,	
459th ,,	,,	,,	
509th ,,	,,	,,	
AUST. CORPS.			
1st Aust. Field Co.	1st Aust. Div.	E.	
2nd ,,	,,	,,	
3rd ,,	,,	,,	
4th ,,	4th Aust. Div.	D.	In Reserve.
12th ,,	,,	E.	
13th ,,	,,	,,	

SIGNALS.

EPEHY. 18TH SEPTEMBER, 1918.

Unit.	Formation.		Remarks.
Third Army Signal Co.		N.E.	
D Corps Signal Co.	IV Corps	,,	
5th Div. Signal Co.	,,	D.	
O Corps Signal Co.	V Corps	N.E.	
17th Div. Signal Co.	,,	E.	
21st ,,	,,	,,	
33rd ,,	,,	N.E.	
38th ,,	,,	E.	
Fourth Army Signal Co.		N.E.	
C Corps Signal Co.	III Corps	D.	
12th Div. Signal Co.	,,	E.	
18th ,,	,,	,,	
58th ,,	,,	,,	
74th ,,	,,	,,	
E Corps Signal Co.	IX Corps	N.E.	
1st Div. Signal Co.	,,	E.	
6th ,,	,,	,,	
Aust. Corps Signal Co.	Aust. Corps	N.E.	
1st Aust. Div. Signal Co.	,,	E.	
4th ,,	,,	,,	

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WATER DIVINING.

By Lt.-Colonel Hugh Rose of Kilravock, c.m.g., late 1st Bn. The Black Watch (42nd).

The writer had the honour to be asked a month ago to pen an article for the *R.E. Journal* with reference to a critique by "H. B.-W." in its March number (p. 171, etc.) on a book entitled *The Divining Rod*, by (the late) Sir William Barrett, f.r.s., and Theodore Besterman.

In his summing up the reviewer says, "The conclusion to which the military reader of this interesting, but rather heavy, work must come, is that an experienced dowser should be available at headquarters of any force in the field to assist the engineer officers responsible for water supply. The want of such an expert was severely felt in the South African War. Many lives would have been saved, and much fruitless labour avoided, if an experienced dowser had been available, for instance, during the long halt at Modder River. Amateur dowsers did their best, but the results were almost nil. Geological data can generally be obtained of a possible theatre of war, but a dowser with experience of local conditions is a *rara avis*."

In the instances given in *The Divining Rod* of my having helped two R.E. Water Supply officers of the III Corps Headquarters in the Great War near Albert, the first case certainly exemplified the fact that weeks of labour were fruitlessly spent in digging and boring for a comparatively small supply. Moreover, worry and anxiety were affecting the officer's health, and it was the fact of his being in my mess, and my happening to ask him one morning what made him look so ill, that led to the water finding described on page 194 of the above-mentioned book.

This article, therefore, aims at suggesting how the excellent conclusion of "H.B.W." may perhaps be attained. But, first of all, a few general remarks on dowsing may not be out of place. My experience, which extends over a period of some twenty-two years, is that a very large number of people have never been aware that such a faculty as dowsing exists. Others who have heard of it, and perhaps seen it, are profound sceptics, and look upon the whole matter as "in some cases as a 'conscious commercial fraud,' (to quote a letter in a well known newspaper last year,) and in others a semi-conscious desire to achieve what is sincerely believed

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possible." Being an amateur, I presumably am included in the latter category of poor deluded mortals, honest maybe, but dotty. This view, as often as not, arises through their having seen some expert demonstrate, and tried to do the same thing, but, through lack of the necessary sensitiveness, have entirely failed to get a pull. They then reason inwardly somewhat in this manner: Why should a forked rod turn in this fellow's hands, while with me, a person of obviously superior intellect, nothing whatever happens? A murrain on the varlet!

All such people should read carefully through the evidence and facts collected in the Barrett-Besterman book. And I am sure that an afternoon's outing with a very gifted professional water diviner of Oxford, whom I had the pleasure of meeting and working with for four days this month (April), would convince the most hardened unbeliever that dowsing is not only a genuine, but a truly marvellous faculty. This is how I first got track of Mr. John Timms, who, by the way, does not happen to be mentioned in *The Divining Rod*, though unquestionably in the front rank of professional water finders. A little over a year ago we were returning from a trip through Corsica, by a Bibby liner from Marseilles. On the promenade deck of our vessel, in Marseilles harbour, a French bookseller had rigged upa bookstall, containing all sorts of British newspapers and magazines. Glancing at the contents on the front cover of each magazine, my eye caught the words on the April *Cornhill*, "Water Divining, Scientific and Commercial." It was the joint production of John Timms and Hyacinthe Daly. The *Cornhill* was at once added to a growing collection of books on dowsing. And, following upon a correspondence with Mr. Timms, a meeting was arranged at Oxford, and proved to be a most interesting and instructive one for both of us. One thing that our investigations and experiences proved was, what I have for a number of years maintained, namely, that hardly any two dowsers work alike, because their supersensitive organisms are different, sometimes in a very marked degree. For instance, Timms's rod turns in the same direction for water, oil and metals. Mine turns the same way as his for water and oil, yet there is quite an unmistakeable difference between the two; water affording a steady pull and turning of the rod, while oil gives a curious quick jerk, which touches up the solar plexus, and either muscles or nerves, on the inner side of my elbows. And for me metals and minerals turn the rod in exactly the opposite way to water. If Timms puts some gold on the ground and holds gold in his hand, his rod remains quite immobile, and I have come across other one or two famous dowsers who have the same happening. If I hold, say, a gold chain in my hand, and approach gold lying on the ground, or floor, the rod turns very much more readily and sooner to the

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latter, than it would without this affinity assistance. Moreover, it will not turn to any other metal on the floor but its like.

This peculiarity led to an amusing incident a few years ago. A wealthy young friend threw a gold matchbox on the ground while we were having lunch out fishing, and said, "Just try that." Gold chain in hand, I went to it, but there was no response. "Hullo," I said, "this is not gold at all." "What, not gold? Do you know what I gave for it?—a tenner." "Well, all I can say is that you have been done down; and I'll lay you an even ten pound note that there is no gold in it at all." He wisely did not bet, or he would, as he found out later, have lost.

One more instance may be given of diversity. At Aldershot, shortly before the Great War, I came across a Brigadier-General generally known as "New Zealand Davies," quite a good hand at divining. His rod turned in exactly the opposite ways to mine. From these three examples of variation it can be realised how important, it is that not only the general public, but dowsers themselves, should be aware of it. Some dowsers are apt to dogmatise on what they believe to be the one and only method, namely, their own. Some, too, have in the past attributed to the rod itself powers which it most certainly does not possess. The rod, watch spring, or whatsoever instrument the dowser elects to work with, is purely an indicator, comparable to the hands of a clock. Whether the rod be whipped round the junction of the V with string, or anything else, so as to prevent, or lessen, the chance of its splitting at the fork, does not impair its efficiency in the slightest degree.

Both Mr. Timms and I concur that there is no better rod than a good symmetrical hazel, that is, one having both sides of equal thickness and strength. It is a tough wood, pleasant to handle, and in spite of being held for long spells in a state of tension, its tendency is to regain its normal V-shape at once when released. But when used for some hours' work it is very tiring to the muscles of the arms and may thereby, if overdone, affect the nervous system. Personally, I find that a good deal of searching for water can be done with a finely tempered watch spring, $\frac{1}{8}$ of an inch in width, without incurring any fatigue to speak of, and it was by this means that I dowsed the water near Albert in 1916-17. But to roughly get at whether there was likely to be a sufficient supply or not, I made use of a pretty stout hazel rod. How to gauge the depth down of the water and the amount per hour in gallons, I had no idea, and made no attempt to predict it. But now Mr. Timms has shown me his method of arriving at these. All the same, I fully realise that much practice and experimenting will be necessary for me, or any dowsing tyro, before we can hope to attain the amazing accuracy of him, and of other first-class professionals of the day. There is assuredly no royal road to it.

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Few, if any, dowsers feel any reaction over stagnant water; it has to be running.

But I can get a pull for water in a finger bowl or even a tea cup placed on the ground.

This supersensitiveness may be useful for indoor demonstrations, but entails disadvantages out in the field.

Mr. Timms and an Oxford University lecturer, A. H. Church, M.A., D.SC., F.R.S., have almost finished a prodigious task, that of mapping out all the underground streams and rivers of Oxford in and around and for some miles outside the city; in all about thirty square miles in area!

In a most careful and painstaking way they have respectively traced them with the rod, and draw them forthwith on the Ordnance maps, nothing being taken for granted or guessed at.

From the positions of the older colleges, several old wells in the city, ancient farms and sites of old monasteries in the mapped area, all placed on natural though unseen streams, they have no doubt but that the monks of old were well acquainted with the faculty of dowsing, and employed those who had the gift before commencing to build.

Mr. Timms took me one day up to a hill where a year ago he traced three or four streams, through a tangle of brambles and undergrowth, driving in at that time a long wooden peg here and there to mark the general line of each, and I saw evidence of this in the shape of five good new wells which I examined while on the site. We came to a depression where some ugly blackish water was oozing down the brae face, and he was impressing upon me the huge mistake which an inexperienced dowser may make in going by surface indications, such as this, instead of trying in some quite unlikely area for a pure supply at a reasonable depth, free from all surface contaminations. The hill had recently been cleared of its scrub, as it is now being built over. He said that from his recollection of the previous year's work, a small stream should be flowing below, and not far from where we were standing. He took out his rod, made a few steps forward and up she went, and at the same moment his toe was actually stubbed by one of his pegs, concealed under a tangle of red bracken. As he remarked, it was a pretty good object lesson in dowsing accuracy.

He and I, working quite separately at metals, found that the rod reacts more readily to nickel than to gold.

What perhaps astonished me more than anything was that when we were sitting on the top of a motor 'bus holding our rods in tension, while crossing a river, they both continued to revolve as long as we were over the water He has found similar action while in an aeroplane 1,000 feet up.

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He also showed me how to differentiate between ordinary and brackish (saline) water, and, under his instructions, I felt an underground river flowing two hundred and fifty feet below us, there being no indication of any sort of its existence.

And now for our suggestions.

Mr. Timms is of opinion that about one in a thousand may be found to possess the faculty of dowsing. Being of a sanguine nature, I am inclined to estimate the proportion as nearer one per hundred. It would be very greatly to the advantage of Great Britain if there was a far better supply of good water to villages and farms than exists at present. In Scotland, many farm wells, foolishly placed in the past and quite unprotected at the top from pollution, become fouled by the drainage from stables and cattle byres. And in many counties in the kingdom a dowser is unknown. We suggest that, just as a small trickle of water becomes a rivulet, a rivulet a stream, and a stream a river, there should be a quite small beginning, working up gradually to a large scheme. Start, say, with one county in England—perhaps the smallest, Rutland—and try out, parish by parish, to see who may possess the gift of dowsing and be likely to devote time and energy in thoroughly mastering the art of predicting depths and quantities of water in gallons per hour. It takes very little time to test individuals over running water. The names and addresses of all likely dowsers should be taken, and a class formed in a market town handy to several parishes. My experience of dowsers is that they are, in general, a very open-minded type of men, ready to help others along. At the same time, they are a busy class, and have, as a rule, little spare time so would naturally require recompense for work which took them away from their daily living. Pupils should be taught a knowledge of geology, but at the same time in their instruction it could not be too strongly instilled into them that they must be guided by the rod and let the geological knowledge prove useful after the water has been located. They should be tested at the end of a course, and given a diploma if passed as capable. Were a moderate sum granted by the War Office or Government to start a trial scheme of this sort, it would be a good beginning towards a solution of obtaining reliable dowsers in war time. And the mere fact of the much-maligned dowser co-operating with the geologist ought to tend to remove the strange prejudice which still strongly exists, even among highly educated people. Without the least exaggeration, had I been given a five pound note for every time since 1904 that the following phrase has been said to me, I could have purchased quite a nice small motor car costing over one hundred and fifty pounds. I know now too well the look that precedes the utterance of the saying, and

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positively dread it. It goes like this (and the speaker seems to think that it is entirely an original one): Do you know, if you had lived two hundred years ago, you would have been burnt as a witch ?" Two or three—more brainy than the others—have added, after a pause, "perhaps I ought to say, Wizard ?" Quite recently I was treated to a novel variation of this formula. "If you were to do that in India, the natives would call it *Jadoo*." Talking of India reminds me that the Bombay Government is employing an European dowser, a Major Pogson, at a considerable salary, and that he has been doing excellent work in his Presidency for several months past.

In conclusion, I may remark that I am at present engaged in trying to solve the problem, "What force turns the rod ?" and hope to have arrived at the answer before the end of the year.

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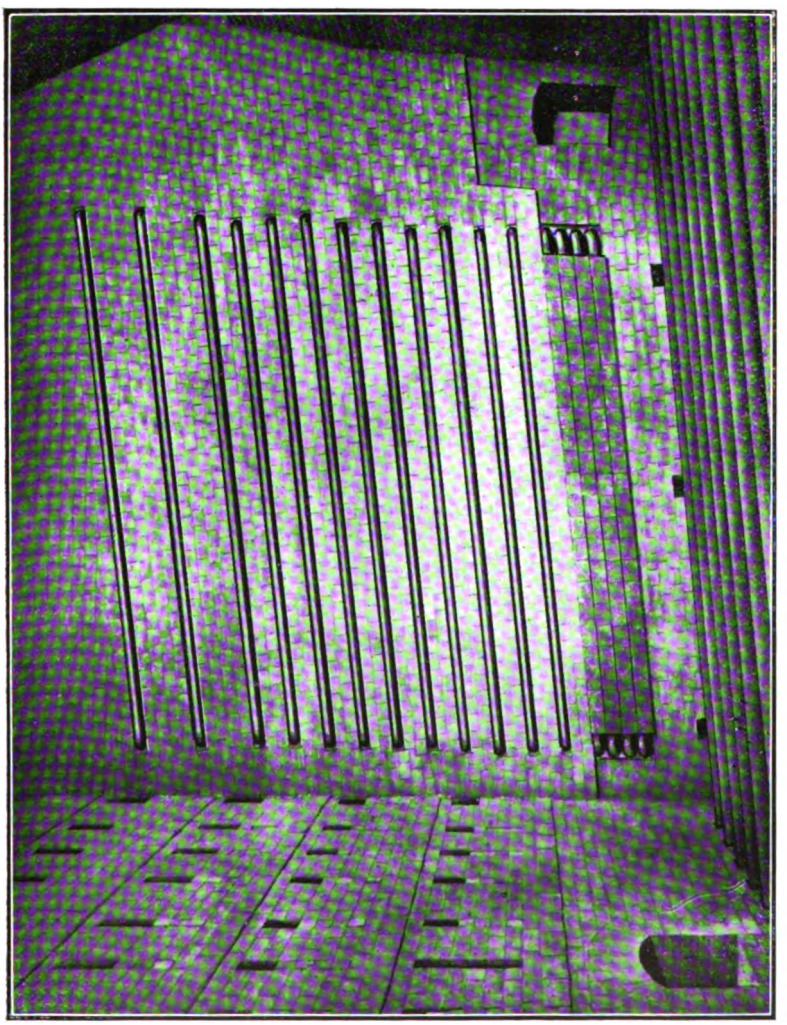

Inside View of Combustion Chamber, showing Water Screen and Water-cooled Walls.

By kind permission of The International Combustion Company.

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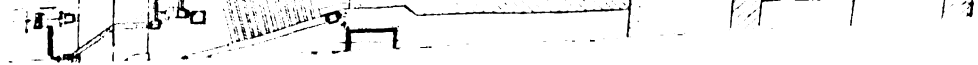

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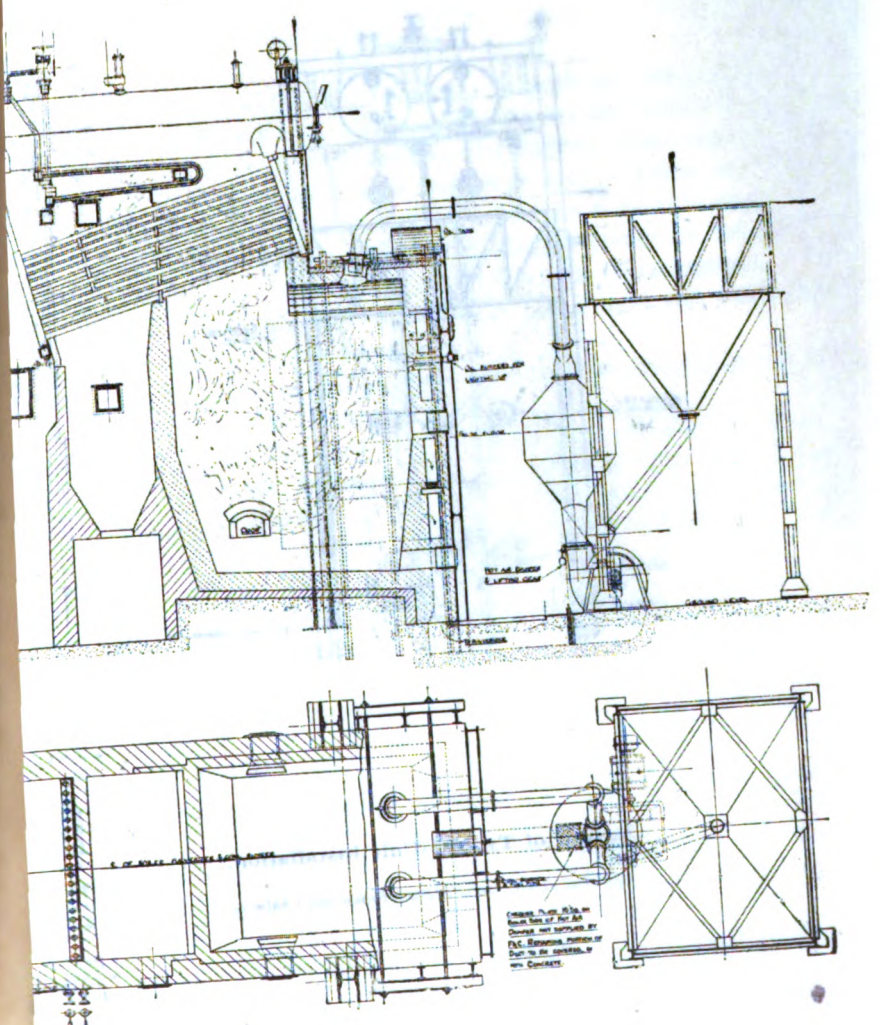

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PULVERISED FUEL FOR BOILER FIRING.

By LIEUTENANT K. H. TUSON, R.E.

IN some branches of industry, notably in the heating of rotary cement kilns, coal has been burnt in the pulverised form for nearly twenty-five years. Since the war this method of firing has been coming into use for steam raising, both for process work and in power stations. So far it has been used to a greater extent in the United States than in this country, but it has now been installed in several of the latest " super " power stations, among others Nechells, Birmingham.

The advocates of this system of firing claim that the following advantages result from its use :—

(1) A much lower grade, and consequently cheaper, fuel can be burnt than with chain grate stokers.

(2) Owing to the very large surface area of coal in a finely divided state, an intimate mixture of coal and air can be obtained. As a result of this and of the absence of a moving grate, much less excess air is used than with stoker firing, and partly owing to this :

(3) The boiler thermal efficiency is high, 86 to 88 per cent.

(4) Riddling losses through the bars of the grate are eliminated, also losses occasioned through coal traversing the entire grate and dropping into the ashpit without being entirely consumed.

(5) Boilers can readily be forced in emergency.

(6) Plant can be started up and put on the range very quickly and easily.

(7) Banking losses are almost entirely eliminated.

(8) Coal in its pulversied form can be transported easily in pipe-lines with little loss.

The plant can be arranged in two principal ways, each of which has its own particular application. For large installations the central system is more usual, and pulverising plant is installed with bunkers for both the raw and the pulverised coal. The pulverising plant may be in a separate building apart from the boiler house, and the coal dust is delivered to the boilers by mechanical means if the distance is short, or more usually, pneumatically, through pipes. In this case fans have to be provided. Drying apparatus must also be installed.

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The pulverised coal bunker enables the pulverising plant to be shut down when required for cleaning, renewals, etc., and also ensures that, in the event of a breakdown, the supply to the boilers will not be interrupted.

For small installations of one or two boilers only, the expense of, and space taken up by, a central system preclude its use. Each boiler is regarded as a separate unit, and is complete with its own pulveriser, driving motor, etc. The pulveriser feeds direct to the burners (usually two) in the boiler combustion chamber. A small fan is incorporated in the pulveriser. Naturally, with this system, any breakdown of the pulverising plant puts the whole boiler unit out of action. The power absorbed per ton and running costs are also greater than with a central system.

One advantage of the unit system is that the danger of spontaneous combustion of the coal dust is removed. At the same time, totally enclosed and, if necessary, pipe-ventilated motors should be used for driving pulverisers.

BETTINGTON PULVERISERS.

The working of a plant will best be understood if a typical installation is described in detail. The particular plant chosen is known as the Bettington, and is manufactured by Messrs. Fraser and Chalmers (G.E.C.), but the main outlines are common to all makes. So far, Bettington pulverisers are manufactured in sizes suitable for unit systems only. Plate 1 shows the general arrangement of an installation.

The plant consists of :—

(a) The pulveriser A. The raw coal is fed from overhead bunkers or by belt into the receiving hopper, from which a friction-driven screw takes it into the pulverising chamber. There, revolving beaters mounted on a steel rotor hammer it against mild steel liner bars, and the coal is broken up until 85 per cent. of it will pass through a 200-mesh screen (200 to the inch). Previous to being fed on to the screw, the coal passes over the poles of a magnet to remove all tramp iron. Hot air is drawn into the pulveriser, sometimes from the combustion chamber walls, made hollow for the purpose. This helps to dry the coal.

The boiler output is regulated by adjusting the rate of rotation of the feeding screw.

(b) A double inlet fan, intergral with the pulveriser. This has three functions :—

(1) To draw in the air mentioned above.
(2) To direct the coal on to the beaters.
(3) To deliver the pulverised fuel to the burners.

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The coal is not actually delivered under pressure; there is a point of balanced pressure half-way along the pipe line and thence the coal is drawn into the combustion chamber by suction.

(c) A mechanical separator B, mounted above the pulveriser. As the beaters and liners wear, the average size of particles delivered from the machine increases. It is essential to deliver particles of a uniform size to the burners, and consequently in any pulverising plant provision must be made for rejecting all oversize particles.

In the Bettington this takes the shape shown in the accompanying plate. The particles on their passage to the burners strike a cone-shaped baffle, which flings them outwards. The large particles are too heavy to be thrown out, and fall down, being fed back into the pulveriser.

(d) The Burners C. These consist of a set of small spiral channels, which split up the fuel and cause it to enter the combustion chamber with a rotary motion. Most of the air necessary for combustion has been drawn into the pulveriser, but arrangements for introducing extra air into the burners are usually made.

(e) The Combustion Chamber D. This is one of the most important features of a pulverised fuel plant, and will be gone into in more detail later in this article. It is essential that the fuel should be completely burnt out before the flame strikes the water tubes.

A vertical tube boiler is better than one with horizontal tubes, as it has a much larger tube surface to receive the radiant heat.

In most plants the burners are placed on top of the combustion chamber and deliver downwards as shown in the figure.

(f) Lighting up arrangements. A small oil tank is mounted above the boiler, and oil delivered through a separate burner lighted with a torch. The consumption of oil is very small.

Other Systems.

Various other pulverised fuel plants are on the market; the only important differences are in the pulveriser and in the design of combustion chamber to avoid the troubles mentioned hereafter.

In the *Fuller Pulveriser* (sold by Babcock and Willcox) and in that marketed by *Simon Carves* for central plant, loose hard steel balls are free to roll around inside the machine. Wear is taken up by inserting fresh balls as the old ones are worn away.

The *Herbert* attritor pulveriser has a revolving element consisting of a disc, on the side of which about thirty cast-iron pegs are fixed. These rotate among a similar set of fixed pegs on the side of the

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casing, and the coal (after a preliminary breaking up with revolving hammers) is reduced to the required degree of fineness by attrition (i.e., rubbing of particles against one another). As a consequence the power used and running cost are low (figures are given subsequently).

The separation of tramp metal is not done magnetically. The coal is air-borne into the machine and the stream of air is so regulated that it has not sufficient velocity to support the metal with its high density.

The uniformity of particle size is also not ensured by a distinct separator, but by vanes on the rotating element, which throw into the pipe-line by centrifugal force all particles which have attained the requisite degree of fineness.

The low power consumption and cheap maintenance (referred to later) appear to be distinct advantages of the Herbert system. In 1926, none of these plants were running in Great Britain in *power stations*, though stations in Melbourne, Australia, and Holland and industrial plants in this country are equipped with it.

Working Results.

Efficiency. Overall boiler efficiencies based on gross calorific value of fuel, of 87-89 per cent., are claimed, but these take no account of power required to drive pulverising plant or anything outside the boiler and economiser.

One plant inspected had been converted from stoker firing, and consequently the above efficiencies were not obtained, but 82 per cent. was obtained consistently over long periods—a great improvement on its previous performance.

Running Cost. In estimating the cost of a pulverising plant the cost of driving the pulveriser is an important item. An average figure for several systems is 25 K.W. hrs. per ton of fuel, but the attritor machine is claimed to absorb only 18 units per ton of fairly dry coal pulverised—a tremendous saving in operating costs. Steam turbines are sometimes employed instead of electric motors for this drive.

Moisture. Coal containing a fairly large moisture content is apt to clog the machine and cause a stoppage. This is a serious drawback to the unit system, where there is usually no dryer. The practicable limit of free moisture is about 10 per cent., though higher figures are claimed by manufacturers.

Renewals. The beaters in the Bettington and other pulverisers of the same type require renewal every thousand hours, and the liners every two thousand. The operation is very simple, a spare rotor being always kept, but the cost of replacements is high, in the neighbourhood of £70 for 2,500 hours running. For the same period £15 will cover replacements to an attritor machine, but the operation takes longer, as all the rotating pegs require replacing

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every thousand hours, and the stationary pegs and hammers every two thousand hours.

Combustion Chamber. The factor at present retarding the spread of this form of boiler firing in Great Britain is that the maintenance of the combustion chamber, owing to the high temperatures attained, is thought to be very high. Hollow walls are used, with water or air circulation in the hollow space, and the designer has to be very careful to allow for expansion.

It is found in some stations that if an attempt is made to run with a high CO_2 percentage (16 or 17) the ash slags badly and refractories melt, and in some plants the figure is kept down to 11. This of course prevents the system giving its best results. The solution to the difficulty is to have a relatively cool zone where the ashes are deposited. This can be partially achieved by a very deep combustion chamber. Messrs. Fraser and Chalmers are experimenting with introducing flue gases into the bottom of the chamber.

The International Combustion Co. (Lopulco and Rayco systems) Herberts, and Simon Carves, insert a water screen, forming part of the boiler circulating system, to cool the bottom of the chamber. This seems to be a satisfactory arrangement, though the cost of upkeep tends to be high. The recent burst of one of these screens was found to be due to lack of water; the low water alarm had gone off, but the attendant had failed to notice it.

Review.

It is now proposed to discuss in turn each of the advantages of pulverised fuel firing mentioned at the beginning of this article. Any advantage mentioned there which is not referred to here may be considered as generally admitted.

(1) In the past few years the ability of mechanical stokers to deal with low grade fuels has greatly increased. This ability is of immense advantage at power stations near pitheads where large waste dumps are available, but at stations a long way from collieries the price difference (in B. Th. U.) in favour of low grade fuel becomes less. It must also be remembered that if pulverised fuel firing becomes widespread, the demand for, and consequently cost of, this fuel will increase, and the price of coal for stoker firing will decrease as the demand for it falls off.

(3) The difference in efficiency over long periods may be taken as about 5 per cent. better than with stoker plant.

(5) Boilers are usually run with rates of evaporation up to ten pounds per square foot of heating surface.

(6) After a boiler has been banked, it can usually take full load within fifteen minutes of being started up.

(8) This advantage, of course, is only gained with the central system. Plants are running in the tropics where coal dust is transported for long distances by pipe-lines through forest.

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One great disadvantage of using pulverised fuel is the difficulty of keeping the boiler alight at low loads. At anything under 33⅓ per cent. of normal load, the flame usually goes out, as the temperature of the combustion chamber is too low to maintain combustion.

CONCLUSION.

In any instance where the firing of new boiler plant is under consideration, a balance sheet, including all items concerned, should be prepared. The table below shows some of the entries, though it is not suggested that it is exhaustive for every individual case.

Comparison of Pulverised Fuel and Mechanical Stokers.
Annual Balance Sheet.

In favour of Pulverised Fuel firing.	In favour of Mechanical Stokers.
1. Annual saving in fuel bill, due to cheaper coal and higher thermal efficiency.	3. Interest and depreciation on difference in capital cost of alternatives.
2. Annual saving in wages.	4. Annual cost of energy required for pulveriser motors, fans, dryers, etc.
	5. Maintenance and renewals for pulveriser.
	6. Extra maintenance of combustion chambers over stokers.

Item 4. If electric drive be used it is considered that the energy be charged at the actual cost per unit generated at the station busbars *exclusive* of all standing charges, as these are unaffected by the few extra units required, but some engineers may prefer to charge it at the total cost of production.

Item 5. This is best obtained from actual figures of the cost of spare parts, etc. Figures of from 1d. to 2d. per ton of coal pulverised are advanced.

Item 6. This is at present the indeterminate factor of which many engineers are afraid. Neglecting it, the balance sheet will usually show a balance of a few hundred pounds in favour of pulverising (the makers may possibly be induced to guarantee the maintenance costs for a short period).

In general, the conversion of existing plant is not advantageous, as the requisite depth of combustion chamber can only be obtained either by digging or raising the boiler drums, both costly processes, even if they are feasible.

At present, too, the consensus of opinion seems to be that pulverised fuel firing is not a commercial proposition with boilers evaporating less that 20,000 lbs. of water an hour, though undoubtedly this is only a passing stage in its development.

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DEMOLITION OF A MASONRY BRIDGE.

By CAPTAIN C. G. MARTIN, V.C., D.S.O., R.E.

THE following account of a demolition recently carried out at Chatham may be of interest and value to officers of the Corps as exemplifying the use of small charges in boreholes.

The bridge consisted of a single span brick arch over a sunken road which was to be widened and deepened to take motor lorries. The bridge itself had long been disused, and its removal by breaking up by hand had been attempted, but owing to the hardness of the masonry the only results obtained at the end of two weeks' work were the removal of the roadway and parapet walls and cutting a small hole in the arch ring.

As the removal of the bridge was urgently required, the R.E. were asked to carry out its demolition with explosives, the only conditions being that the abutment wall "A" on the east side be left standing undamaged and that the debris be broken up to such a size that it could be removed by hand. (See sketch A.)

Dimensions of bridge :—

Span	10′
Width of abutment	11′
Thickness of arch ring	18″
,, abutment piers	3′
Height of arch above ground	13′

Material of construction :—

Burnt brick in Portland cement mortar.

Owing to the situation of the bridge, in a populated area, within 60 yards of a row of cottages, 200 yards of a public road, and 500 yards of an acre of greenhouses, only small charges could be fired, and contact cutting charges on the arch ring and abutment pier, amounting to 19lbs. and 90lbs. respectively, were out of the question.

It was therefore, decided to experiment with bore-hole charges

Three distinct operations were involved :—

(1) Demolition of arch ring and its springing by charges below and behind the springing course in abutment "B."

(2) Demolition of a pier abutment "B" by charges in the centre of the lower portion of the pier.

(3) Demolition of the arch ring where it joined the abutment "A" to cut any portion remaining after operation (1) had been carried out.

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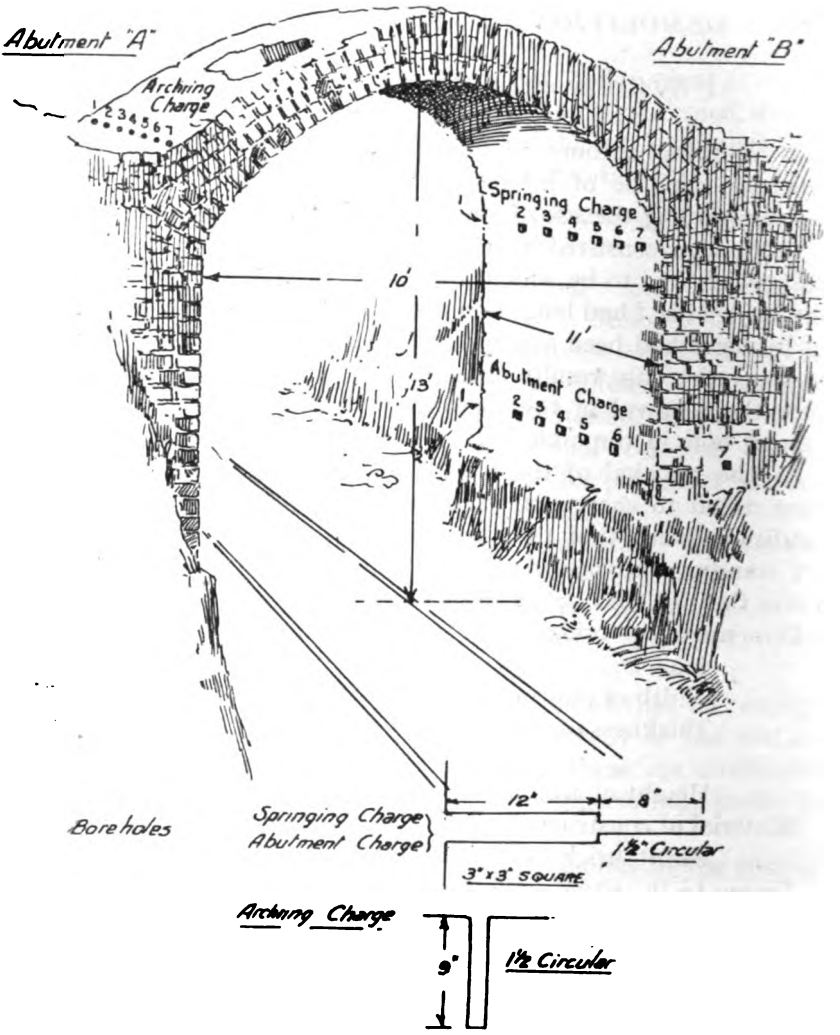
SKETCH "A"

Position of Boreholes



Calculations for charges.

(1) *Springing charge.*

Depth to centre of charge=1' 6".

$C=\frac{L^3}{6}$ where L=3/2'. (Page 60 *M.M.E.* Vol. IV.)

=9 ozs.

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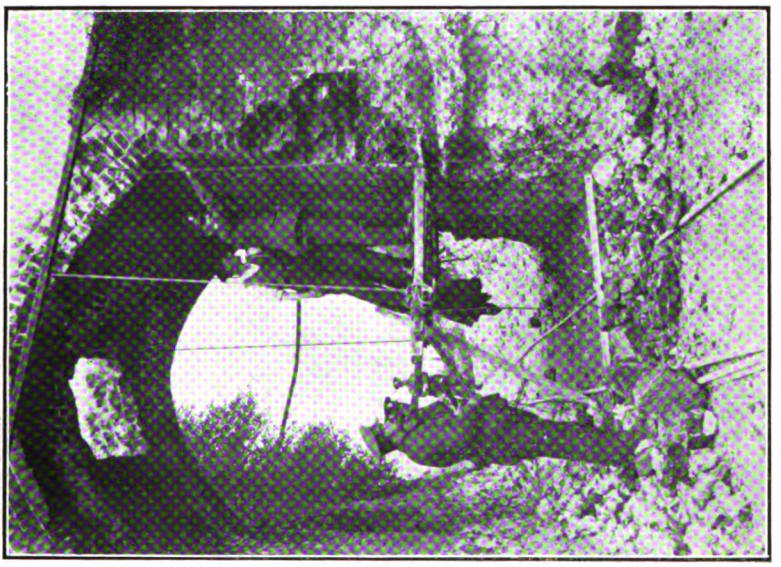

Fig. 2.

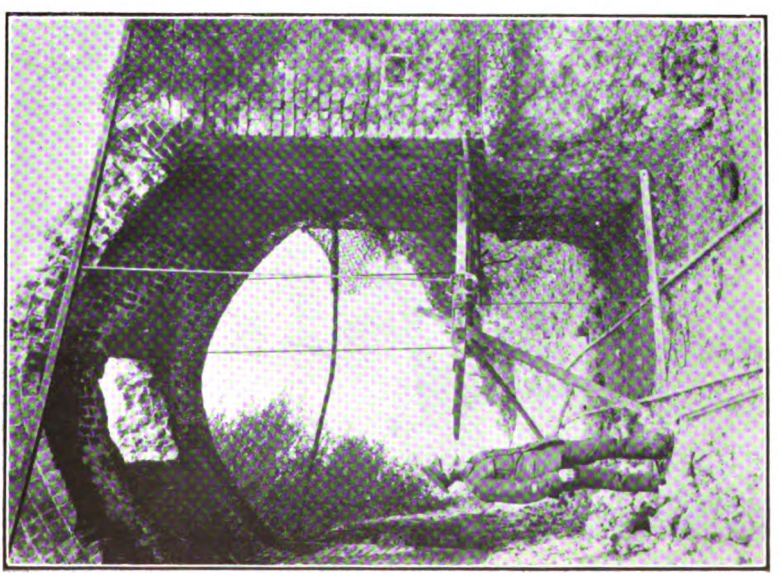

Fig. 1.

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Fig. 3.

Fig. 4.

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Fig. 5.

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Fig. 6.

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Spacing of charges $=\frac{4}{3}L=24''$

(2) *Pier abutment charge.*
Thickness of pier=3′

$\therefore$ L=3/2′.

$\therefore$ Charge as or springing charge=9 ozs.
spacing of charge=24″.

(3) *Arch ring charge.*
Thickness of arch ring=18″

$\therefore$ L=3/4′.

$C=\frac{L^3}{6}=1\frac{1}{8}$ oz.

Spacing of charges $=\frac{4}{3}\times L=12''$

Tota' Charges from calculations.

(1) Springing.	5 charges of	9 ozs.	at 22″ interval=	3lbs. 7 ozs.
(2) Pier.	5 ,,	9 ozs.	at 22″ interva'=	3 lbs. 7 ozs.
(3) Arch ring.	9 ,,	1⅛ ozs.	at 12″ interva'=	10 ozs.
			Tota'	=7 lbs. 8 ozs.

For convenience, to suit the working party reliefs and available tools, the following bore-holes were driven for charges :—

(1) Springing. 7 bore-holes at 16½″ interval.
(2) Pier. 7 ,, ,, 16½″ ,,
(3) Arch ring. 7 ,, ,, 15″ ,, Sketch A.)

Bore Holes.

The bore-holes for the springing and the pier charges were made from a slung platform (Photo 1) ; the first 12 inches were made with a 18″×1¼″ chisel and a 4½lb. hammer, mason, cutting a 3″×3″ square hole.

The average time taken for the 12″ hole was 45 mins.

The last 8″ consisted of a 1½″ round bore-hole, made with a 4′×1½″ boring bar No. 3 and a 7-lb. hammer.
The holes were bored dry.

The time taken for the ast 8″ in the springing series, where the hammer was used above the head, was 135 mins., and in the pier series 75 mins.

With the bore-holes 16½in. apart, it was necessary to work in

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two shifts, the total time taken being 6 hours for the springing and 4 hours for the pier.

For the arch ring bore-holes, the No. 3 boring bar and 7-lb. hammer were again used, but the hole bored wet.

The time taken for 9" depth was 45 mins.

Working in two shifts, the total time was 90 mins.

The above figures were with recruits who had no previous experience in the use of these tools.

Charges Used.

Test Charge (see Photo 1).—Bore-hole No. 7 in abutment "B" was charged with four 1-oz. gun-cotton primers and fired by F.I.D.

The charge was less than half the calculated charge of 9 oz.

Result is shewn in Photo 2.

The corner of the pier was blown out, and the pier was cracked down to the foundations on the inner face.

Springing Charge.—It was decided to charge bore-holes 1 to 7 of the springing charge with four 1-oz. guncotton primers each and to fire electrically, covering the top of the pier with torpedo netting.

After individual test, the seven No. 13 detonators were inserted in the charges and the bore-holes tamped with clay.

On testing for continuity before firing, it was found that the No. 13 detonator in bore-hole No. 1 was defective; this was disconnected from the circuit and bore-holes No. 2 to 7 were fired.

Result is shown in Photo 3.

Larger portion of the arch ring was blown away.

Charges 3 to 7 successfully blew out the springing, but charge 2 blew out on top of the abutment. The portion of springing above charge 1, which was not fired, and above charge 2, which blew out the other side of the pier, remained in position though badly cracked.

Abutment Charge.—The abutment bore-holes No. 1 to 6 were charged with three 1-oz. guncotton primers each and fired by F.I.D. branches, which passed through the primers after taking off from the main F.I.D. by hammered twisted joints.

The main F.I.D. was fired by one No. 8 detonator, attached to it by a brass union. (See Sketch "B.")

Result is shown in Photo 4.

A wedge was cut out of the abutment for full length, the whole pier was cracked and was only kept standing by the earth bank behind.

The remaining portion of the arch ring was cut from the pier, but kept in position by its own weight.

Arch Ring Charge.—Bore holes Nos. 1-7 were charged with two 8-oz guncotton primers and fired by F.I.D. as for the pier.

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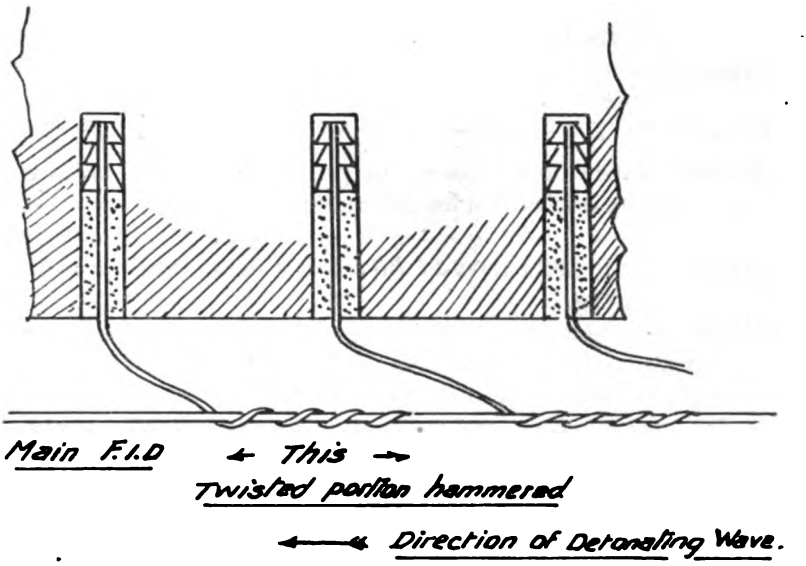
SKETCH 'B'

Method of firing Borehole Charges with F.I.D.



Initial detonation of F.I.D.

Result as in Photo 5.

The arch ring was cut off and dropped, with the pier abutment, on to the roadway.

Breaking up.

Seven bore-holes, 9in. deep, were made in the larger blocks of masonry, charged with two 1-oz. guncotton primers and fired electrically.

Result as in Photo 6.

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Total Charges Used :—

Springing	=	24 ozs
Pier	=	22 ,,
Arch ring	=	14 ,,
Breaking up	=	14 ,,
		74 ozs=4⅝ lbs.

POINTS BROUGHT OUT BY THE DEMOLITION.

1. *Demolition of Pier.*

The formula $\frac{L^3}{6}$ is ample and the spacing of charges $\frac{4L}{3}$ is suitable for working where both sides of the pier can be got at, holes being driven from the opposite sides alternately.

2. *Demolition of Brick Arch by Bore-hole Charges under and behind Springing.*

(*a*) The bore-hole should be bored to a depth so as to bring the centre of the charge at a distance from the face at least equal to thickness of the arch ring.

(*b*) To enable work to be carried out at all bore-holes simultaneously, the spacing of bore-holes must not be less than 3′; this will necessitate a larger charge. For an arch ring 2′ in thickness the charge required, spaced at 3′ intervals, using $C=\frac{S}{\sqrt{10e}}\ L^3\ (\sqrt{1+n^2}-0.41)^3$ formula (*M.M.E.*IV, page 152)

taking $S=4$

$e=3$

works out at 2 lbs.

3. *Bore-holes.*

For untrained men, a square or rectangular hole in masonry is more rapidly cut than a circular bored hole. From tests carried out, a square hole 9″×9″ can be cut with brick chisels to a depth of 3′ at the average rate of 1′ an hour, so long as the direction of the hole coincides with the courses of brick work.

If boring bars or jumping bars are employed, holes should, where possible, be bored wet, thus reducing the time taken.

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TRADE TESTING AND TRADE TRAINING.

By CAPT. R. P. A. D. LITHGOW, R.E.

WHILE it is neither possible nor desirable to deal exhaustively with the subject of Trades Organization generally in an article such as this, it is thought that there is, perhaps, especially among junior officers, some lack of understanding of the methods of trade education employed in the Corps and of the qualifications which are to be expected of a tradesman.

As a basis upon which to work it is essential that the general classification of Trade Groups and Rates should be known.

The detailed composition of the trade groups, together with the authorised trade tests for each class, is laid down in " Regulations Governing the issue of Tradesmen's Rates of Pay, 1923," originally issued with *Army Orders* for December, 1923, and considerably amended subsequently. A rough classification may, however, be of value, to enable officers to understand more readily the broad principle or framework on which Corps trades are organised.

COMPOSITION OF TRADE GROUPS.

The Trade Groups are arranged by letter, ranging from A to E, the higher group trades carrying the greater rates of pay for men of similar standard, or class, in their respective trades.

Each trade in groups A, B, and C, is subdivided into three Classes, I, II and III ; Groups D and E contain Classes II and III only, Class II for certain Group E trades being authorised by *A.O.* 213 of 1925.

Group A trades are, broadly speaking, those requiring considerable theoretical knowledge and/or practical experience over a period of years.

As typical examples, more commonly met with in the Corps, may be instanced *Draughtsman* (*Architectural* or *Mechanical*) ; *Fitter* ; *Patternmaker ;* and *Surveyor* (of various kinds).

Group B trades contain the majority of the normal Building and Workshop trades, such as *Blacksmith, Bricklayer, Carpenter and Joiner,* and so on.

Group C comprises normal trades requiring less training and experience, or less skill, than those in Group B, some of the commoner examples being *Painter and Decorator, Riveter* and *Tinsmith and Whitesmith.*

Group D consists of rather lower category trades and, as previously mentioned, these trades are divided into two classes only, there being m Class I rate.

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Examples are *Concretor, Driller* (*Machine and Hand*), and *Sawyer.*

Group E is composed of semi-skilled trades, such as *Blacksmith's Striker* or *Hammerman,* and also contains men who are classified as semi-skilled at a Corps trade of higher category. The latter are enlisted as Pioneers in their trades, e.g., *Pioneer* (*Carpenter and Joiner*) or *Pioneer* (*Bricklayer*).

Men who show more than ordinary semi-skilled knowledge of a trade but who cannot be classified as Class III tradesmen, owing, perhaps, to their experience being limited to certain branches of the trade only, may be passed as Pioneers F. and recommended for six months' trade training on completion of their Recruits course.

Further details are given below under the head of "Trade Training."

It should be noted that men, whether tradesmen or Pioneers, can only be enlisted into the Corps when they have trade qualifications in a recognised Corps trade, and that all the trades listed in the Regulations referred to are not applicable to R.E.

Men are also enlisted on normal rates of pay (as for infantry) if they have no useful knowledge of a recognised trade, but can subsequently be mustered as *Pioneers R.E.*, without knowledge of a Corps trade, provided that they obtain a certificate from their C.O. that :—

(i) They are above the average in intelligence, with a fair amount of education, equivalent to the standard of a third class school certificate.

(ii) They have satisfactorily passed through a course of fieldworks.

Qualifications for Trade Rates.

The detailed qualifications and tests for the different classes of all trades are laid down in the Regulations referred to above, and it is not proposed to go into any further detail here. As a rough guide to the method of classification, however, the following may be found of some use.

The Pioneer is a semi-skilled man only and more or less corresponds to a Learner or Mate in civil life.

The Class III tradesman is a skilled man as far as manual dexterity is concerned, but is only expected to work under supervision.

Broadly speaking, he should be able to carry out the actual work on any but complicated jobs, but cannot be made responsible for the setting out of the work, nor must he necessarily, except in certain specified trades, be expected to work from a sketch or drawing. His qualifications correspond roughly to those possessed (in theory) by a Journeyman in civil life.

The Class II tradesman should possess considerable manual skill and should be able to carry out the work on quite complicated

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jobs. He should also be able to work to a sketch or drawing and to make simple sketches, and to set out work such as is normally met with in his trade.

The Class I man corresponds to the foreman in civil life.

He should possess manual skill to the same, or possibly to a slightly greater, degree then the Class II tradesman, but it should be backed by considerable experience, enabling him to undertake work of any kind within his trade, to supervise men of lower categories, to read and make drawings and set out any class of work, and to estimate quantities. In fact, given a sketch or verbal instructions, he should be able to start the work, draw the requisite stores and materials, and supervise, or himself perform, the whole job from start to finish as far as his own trade is concerned.

These remarks are necessarily brief and very general in character, but any officer should, with the assistance of the Regulations concerning Trade Rates, be able to assess fairly accurately a man's qualifications if the above rough guide is kept in mind.

Trade Testing.

As regards the method of carrying out the actual trade test, it is difficult to lay down any definite procedure. Full details of the standard tests are laid down in the Regulations, but there are a few points which must always be borne in mind by officers to whom Trade-testing duties are delegated or who wish to recommend a man in their unit for a further test, with a view to increase of Trade Rate, by the Trade-Testing Board.

Trade testing is, of course, almost entirely a matter for experience, and an officer who has had no practice, and who probably has only a somewhat superficial knowledge of the actual manual work, must be largely guided by an N.C.O. or Sapper who is himself a good tradesman and has a knowledge of the standard to be expected.

A few words of warning and advice may not, however, be out of place here.

Firstly, then, a trade-testing officer must be fair to the recruit or sapper under test. It must always be remembered that local practice, especially in the building trades, varies in different parts of the country. It is not, therefore, reasonable to fail a man merely because his *method* of obtaining a result differs slightly from that of standard practice in the Corps (or possibly only from that of the tradesman expert whose advice is being sought). It is really the result which matters.

The way in which a man handles his tools and the way he starts to work on his job are usually very sound indications as to his capabilities.

Secondly, it is equally, if not more, important, to be fair to the man's future Company Commander and to the tradesmen already in

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the Corps. Too much lenience in testing is an evil which cannot be too strongly deprecated.

A man who is not worth his trade rate is a nuisance and may even be a danger. This point appears quite obvious without further elaboration, but the possible case of a man who was, for the sake of example, barely up to Class III standard on enlistment and has not worked at his trade since, but is "given" his Class II rate on service because he is, let us say, a very good Officers' Mess cook, has been met with in practice. It should not be lost sight of that the same individual may perchance subsequently be posted as an instructor in his trade. Unfortunately, the irony of fate rarely ensures that the "testing" officer in his case shall also be in charge of the Trade School concerned!

It must not be thought, in consequence of this, that the standard trade tests must be rigidly adhered to in all their details. In the first place, a man's capabilities should always be tested by questioning as well as by his practical work. The length of his experience; the class of work on which he has been employed; his knowledge of practical details of normal jobs within his trade not brought out by the practical test-job given; his general knowledge of constructional or workshop methods which affect his trade and those others with whom some liaison may be necessary or desirable; all these points should be taken into consideration and may turn the scale in either direction.

Further, it should always be remembered that the trades approved and laid down for enlistment into the Corps do not exactly correspond to the trades recognised in civil life.

One example should serve amply to illustrate this point.

Under what one may broadly classify as Plumbers trades there are in the Corps but two approved trades, namely *Plumber and Gasfitter*, Group B, and *Tinsmith and Whitesmith*, Group C.

These two trades, in the higher rates, embrace a knowledge of several entirely distinct civil trades, such as Plumber, Gasfitter, Tinsmith, Whitesmith, Coppersmith and Panel Beater, to say nothing of "Hot Water Engineers" and "Sanitary Experts."

Thus, although the Class III trade tests are usually so arranged as to admit a man skilled in one civil branch only, it will be found that in many cases he has to combine two or more such branches before he can qualify for a higher rate.

In some trades the supply of men of the required standard of skill cannot adequately be maintained by direct enlistment and therefore recourse has to be had to training, the methods of which are further discussed below.

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Trade Training.

Trade Training, to supplement the supply of tradesmen obtainable by direct enlistment, may most conveniently be divided into three categories, namely :—

(i) The training of Pioneers.
(ii) The training of Normal Rates men.
(iii) The training of boys.

The training of men who are already tradesmen with a view to their qualifying for a higher trade rate is considered to be beyond the scope of this article and must in any case depend upon local conditions and facilities.

In the ordinary course of events, both boys and Pioneers F. are given their trade-training before being posted to a unit, but in some cases this devolves upon the company, and it is of great importance that the fullest possible use should be made of such facilities as do exist locally for the training of buglers and men, whether already classified as Tradesmen or not.

(i) *The training of Pioneers.* The ordinary Pioneer and the normal rates man, of course, receive no trade training at Government expense before proceeding to their units. There is, however, a distinct class of man known as the Pioneer F., who, provided there are sufficient vacancies in establishment in his trade, receives a six months' course of instruction in his trade. This course is given at the S.M.E. on conclusion of the man's recruit training and before he proceeds to a unit.

Men who fail to reach the Class III standard in some particular, but who have a good knowledge of the use of the tools, are worth considering for six months' training. Here again the difference between Corps trades and trades in civil life has a definite bearing. For instance, a man who has had fair experience of outside carpenters' work, such as roofing, flooring and fixing and hanging generally, but has done little work on the bench, will probably be worth classifying as a Pioneer (Carpenter and Joiner) F., provided that his method of using the tools and the neatness of his work are promising enough to warrant the belief that after his training he will be well up to the Class III standard.

Similarly, a " brush-hand," with a good knowledge of ordinary painters' methods and plain painting, who has perhaps done a little glazing or paperhanging, but has not sufficient skill at either to pass Class III, and has had no opportunity of practising colour-mixing, is probably worth passing as a Pioneer F, although, of course, no guarantee can be given that there will be sufficient vacancies in his trade to allow of his being trained further at Government expense.

As regards the actual method of training adopted at the S.M.E. in the case of such men, the requirements of each individual are kept in

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view as far as possible, but in general the men are put to work in the shops concerned, where they take a considerable part in the ordinary work which is being turned out.

In this way, in addition to special and definite instruction, they obtain, during their six months, a very fair experience of different classes of jobs such as are met with in Army shops, which, of course, include repair work as well as original construction. In many cases, where the man has had a fair grounding in his trade before coming up as a recruit, he may, if he works hard, come near the Class II standard on completion of his course, though the passing of the Class II test immediately after the period of training is an extremely rare occurrence, owing to the lack of general experience. In the majority of cases the Pioneer F, on passing Class III at the end of his course, will be a more useful tradesman than the recruit who has just managed to qualify as Class III on enlistment.

(ii) *The training of Normal Rates men.* Courses of instruction in certain trades, most of which are peculiar to the Corps, are held at the S.M.E., at the S.E.L. Gosport., and elsewhere—particulars may be found in *Corps Memo.* No. 634, Part II.

For certain trades, e.g., *Engine Hand* (*I.C.*), *Stoker* (*Stationary Engines*), and *Well Borer*, definite courses are held as required and at fairly regular intervals.

In other trades, in which the available supply of tradesmen from normal sources is insufficient to maintain the authorised establishment in the Corps, classes may occasionally be held in order to make up deficiencies from selected Normal Rates men, such classes being formed at the request of O $^{i}/_{c}$ R.E. Records. For example, three classes were held at the S.M.E. for the training of Bricklayers during 1925 and 1926.

It must, of course, be realised that it is impossible to transform a Normal Rates man, however keen and willing he may be, into a tradesman in any desired trade during a comparatively short course, up to about six months in duration.

Even in the case of trades such as that of bricklayer, in which the knowledge required is more or less stereotyped, it is impossible to do more than produce a good degree of manual dexterity, the gaining of the experience which must mean so much to any tradesman being left to subsequent general employment.

The only reason for the possibility of turning out reasonably good tradesmen in so short a time, as compared with that required in civil life, is that, in the Army, men on such courses receive continuous, definite and individual instruction with one end in view, whereas in civil life the embryo tradesman has too often to pick up what he can while labouring for others.

(iii) *The Training of Boys.* Two distinct classes of boys receive trade instruction :—

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(a) Apprentice Tradesmen.
(b) Buglers.

The former have now to pass a competitive educational entrance examination before enlistment, and on the whole, the class of boy now coming up for training is distinctly good.

Until 1st January, 1927, the majority of Apprentice Tradesmen for the Corps were trained at the S.M.E. but, except in the case of certain trades, these boys are now to receive their training at the Boys' Technical School at Chepstow.

The Bugler, of course, is primarily enlisted as such, but, on qualifying in bugle calls, is sent in for trade training in a selected trade at the S.M.E. The greater proportion of them are found to be keen and, although they put in less time in the shops than the Apprentice Tradesman, some very good tradesmen are turned out from amongst them.

In the normal course of events the boy starts his training at the age of about 15 to 15½ and continues until his 18th birthday, when he becomes due to join the ranks as a sapper. During this period he is put through a progressive course of training, essentially practical in character but containing some theoretical instruction in the form of lectures on building or workshop practice, which is punctuated every six months by graduated Regulating Tests.

The passing of these regulating tests affects the rate of pay received, but is by no means a foregone conclusion, though comparatively few boys fail to pass at the end of the minumm period, except in cases where much time has been lost through sickness or similar causes.

The number who definitely fail and are put back for a further six months is very small.

The trade standard reached by most boys on joining the ranks is high, in fact much higher than that of the average recruit.

The principle adopted, as far as possible, is that a boy, on completion of his trade-training, should attain the Class II standard, as as far "manual dexterity" is concerned, though he can only be rated as Class III, owing to his lack of general experience. He has, however, been thoroughly grounded, and the average boy should find little difficulty in obtaining his Class II rate within a reasonable period after joining his unit.

In conclusion, it is hoped that the foregoing may perhaps help towards "a better understanding on the part of all concerned of the 'trade problem' to be solved in the Corps and the method adopted for its solution." [*Corps Memo.* No. 634 Part II. Sec. 1. (2).]

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MAJOR-GENERAL A. EMMETT AND NAPOLEON.

By F. E. G. S.

ANTHONY EMMETT was born in 1789, and received his first commission in the Corps of Royal Engineers in 1808. Early in 1809 he joined the Army in the Peninsula, and remained with it to the end of the war, except for the period from April, 1812, to October, 1813, which he spent in England recovering from a wound received in the capture of Badajos. His experiences of active operations are given by him in the following list :—

" 1st. At Abrantes, and skirmished near it whilst the French were in front of the lines of Lisbon.

" 2nd. In 1811, at both the sieges of Badajos. At the cavalry affair at El Bodon, and occasionally in the trenches before Ciudad Rodrigo, though sickness prevented him taking duty. Prior to the siege he was occupied in improving the navigation of the Upper Douro, to facilitate the transport of supplies for that operation.

"3rd. At the siege of Badajos, in 1812, and at the assault, he led on one Portuguese column of the 4th Division to the breach of the curtain. Severely wounded in the covered way, he was conveyed to the hospital tent, and eventually sent to England for the restoration of health. He believes he was the only subaltern Royal Engineer with a column who was not killed on that perilous night. . . .

" He joined the Army as Captain in November, 1813, and was employed in the examination of the fords of the Nive—held by the enemy's posts—prior to the successful passage of the river, reporting thereon direct to Headquarters and also to Lord Hill. In every instance his report proved correct.

" During the following campaign he was attached to the 2nd Division, and was present :

" 1st. At the battle of St. Pierre, near Bayonne, on the 13th December ;

" 2nd. At the attack on the Heights of Garris, St. Palais, at Tarbes, and other minor affairs ;

" 3rd. At the battle of Orthes ;

" 4th. At the battle of Toulouse."

Besides his wound at Badajos, he was twice slightly wounded.

" Soon after his return to England he was sent with General Keane on the Expedition to New Orleans, landed with the advance

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and was present in the attack of the Americans on that night, at the assault on the enemy's lines and siege of Fort Bower."

On his return to England in 1815, he received the appointment of C.R.E. at St. Helena, and sailed on the *Phaeton*, frigate, in January, 1816, with Sir Hudson Lowe and his staff and the 7th Company, 4th Battalion, Royal Sappers and Miners. They landed at St. Helena on the 14th April, and among some papers recently presented to the Corps by Mr. A. H. Emmett, son of the General, are the original " Memoranda for the Guidance of the Officer in command of the Engineers at St. Helena," in Sir Hudson's handwriting, and signed by him at James Town on the 3rd May. It is a formal document dealing with works and working parties and accounts, but twice mentions works in connection with " General Bonaparte's establishment." It is characteristic of Lowe that he wrote : " No works of any kind to be undertaken without the written approbation of the Governor."

Emmett kept a diary, and though he unfortunately destroyed most of it in his old age, as he considered that the horrors of war were best left unrecorded, he preserved the portion of it dealing with his experiences in St. Helena, and a copy of this is among the papers and has been placed in the Corps Museum. (It has already been published in America, in the January, 1912, issue of *The Century Magazine*).

He had one, and only one, interview with Napoleon. As he had to make a report on the defences of the island, it was not until the 20th July that he was able to pay his respects to the Emperor. He was accompanied by Lieut. Jackson, a sort of attaché to Sir Hudson, and Counts Bertrand and Montholon were in attendance on the Emperor. He was received graciously, and, in reply to Napoleon, said that he was the Chief Officer o fEngineers, and that he had served both in the Peninsula and in France, under both Wellington and Beresford. When asked if he was in the lines at Lisbon, he said " no," but in those of Almada, on the opposite side of the Tagus, but that he knew the lines well. Napoleon said, " Masséna made a great mistake. He ought to have attacked them immediately on coming before them." Emmett expressed his doubts as to the success of this action ; the lines had been long in preparation—were well armed with artillery—and our Army had retired on them in good order. He replied : " That might be, but it was Masséna's only chance of success—by pushing *tête baissée* into them he might have carried them. At all events, it would have been better than rotting before them. Turenne and Montecuculi both said, ' give no time to your enemy to entrench.' " Emmett here remarks that General Sir George Murray, in a later conversation, agreed that Masséna would have had a fair chance of success, as our Army entered the lines in a very disorderly state.

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Napoleon mentioned Masséna's defeat at Busaco, and exclaimed with wrath and indignation, "Why did he not acknowledge it? We must all be beaten at one time or another." After some discussion about the siege of Badajos, Napoleon mentioned Burgos, which he said he remembered well, and asked if a strong redoubt, which he had ordered, had been made there. Emmett answered, "Yes, a horn-work had been constructed, which was carried at once by assault." This rather startled him, but Emmett explained that while columns attacked the fronts unsuccessfully, another attacked the gorge and forced the palisades, but that the losses were heavy.

After that they discussed the battle of Toulouse, and Emmett criticised Soult for allowing an army to file across the front of his position and between it and the difficult little stream, the Ers. To this he listened with attention, and asked some questions.

Emmett here remarks that in a subsequent conversation with Sir George Murray, the latter said that the Duke's plan was to force the passage of the Ers, and that he, Sir George, suggested the desperate expedient of filing between it and the position. He says, "The Duke's plan would have failed, and Murray's ought to have done so."

Emmett also criticised Soult for not attacking Beresford while the latter was isolated for some days, before the battle, by the rapid rise of the Garonne. To this Napoleon appeared to acquiesce, and a later conversation with Montholon confirmed this impression.

After some further conversation, Napoleon pointed to a new battery at Prosperous Bay, and, asking, "What is to attack us there?" laughingly added, "The rats!" Then "Jusqu' au revoir."

After that, the Emperor asked Lieut. Jackson if he also belonged to the Engineers. On receiving the reply: "No; to the *Etat Major*," he most pointedly bowed him out, no doubt supposing him to have been sent by Sir Hudson to overhear what passed, "which," adds Emmett, "was most probably the fact."

Emmett had many other opportunities of speaking to Napoleon while he was building the new house at Longwood, but, after consulting Sir Hudson Lowe, he considered it safest to act upon the latter's advice, "I should take off my hat to him and pass on." But he saw a lot of Count Montholon, and lent him many books, which were returned to him profusely annotated in Napoleon's vile handwriting. Most of these he gave away, but one, "Histoire de la Campagne de 1800 en Allemagne et en Italie; par M. de Bulow, Officier Prussien, Auteur de l' Esprit du Système de Guerre Moderne; traduit de l'allemand par Ch. L. Sevelinges. (Paris)," remained in his possession, together with a transcript of Napoleon's notes, which were deciphered by Count Montholon to Capt. Wortham, R.E., and Emmett. In 1831 the latter republished the book (Londres:

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Chez Whittaker, Treacher et Arnot) with Napoleon's remarks as footnotes. The Corps Library in London is the fortunate possessor of a copy of this rare book, it having been recently transferred to London from the Dublin Branch. Bulow's book is rather a criticism than a history, and Napoleon's 148 notes are interesting not only as comments on the action of Moreau, in view of their well-known rivalry, but also on the art of war in general. Unfortunately, the original book was lost.

On the death of Napoleon, Emmett received orders from Sir Hudson Lowe to make the grave. The way in which he carried out this work is best explained by a quotation from another document, a Report, dated 19th October, 1840, by Captain C. C. Alexander, the then C.R.E. at St. Helena, to the I.G.F., " transmitting a detailed report of the exhumation of the remains of the late Emperor Napoleon, etc.," a copy of which is included among the General's papers, and was also published in *The Century Magazine.*

" The Commissioners first caused to be removed the iron railing surrounding the tomb, with the stone coping upon which it was fixed. The surface of the tomb, covering an area of 11 ft. 6 in., consisting of 3 slabs of wrought stone 6 inches thick, fixed in solid masonry and secured by bands of iron, was raised and completely removed by half past one o'clock ; there then appeared a retaining wall 16 inches thick, forming, as was afterwards ascertained, the 4 lateral sides of a stone vault, 11 feet long, 4 ft. 8 in. wide, and 8 feet deep. This vault was filled with earth to within 6 inches of the 3 stone slabs just removed. After having thrown out and removed the earth, there appeared at the depth of 6 ft. 10 in. a layer of Roman cement, covering the whole area bounded by the 4 side walls. The earth being completely removed by three o'clock, the Commissioners descended into the Tomb, and ascertained that it was perfect and untouched on all sides. The layer of cement being picked up and removed, there appeared a horizontal bed of masonry, 10½ in. thick, of hard stone strongly cemented and secured by iron clamps, which it required four-and-a-half hours to take up. The extreme difficulty of this part of the operation made it necessary to give directions to excavate a ditch parallel to the left side of the vault, and take down the masonry of this side in order to gain an entrance to the sarcophagus by the side, if the masonry of the surface should resist the efforts making at the same time to remove it, but this masonry having been completely taken up by eight o'clock, that part of the operation was discontinued when it had reached a depth of 6 ft. Immediately under the bed was found a strong stone slab, 5 in. thick, 6 ft. 7½ in. long, by 3 ft. broad, forming, as was afterwards ascertained, the upper surface of the interior sarcophagus of wrought stone containing the coffin. This slab was found quite entire and untouched, and was firmly secured to the lateral sides by strong masonry, built with Roman cement, which masonry was perfect.

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" The masonry between the slab and the sides was then, with care, removed, and two Louis's let into the slab. At half past nine o'clock all was ready for opening the sarcophagus. . . .

" The Commissioners then descended into the tomb to inspect the coffin, which was found sound, with the exception only of a small portion of the bottom, which was slightly decayed, though lying on a strong stone slab placed at the bottom of the Tomb, resting on wrought stone pillars. . . . "

Napoleon died at sunset, on the 5th May, 1821, and was buried on the 9th, at 2.30 p.m. The site of the grave was pointed out to Major Emmett by Sir Hudson Lowe on the evening of the 5th, so that the vault and sarcophagus must have been made at great pressure, even though Emmett had probably prepared the design beforehand. He used large flagstones, which had been sent from England for the kitchen of the new house, for making the sarcophagus.

He writes: " The last words Napoleon was heard to utter distinctly were, ' Tête d'armée' . . . The body was laid out in his green coat, etc., on the bed and in the room where he died, in the cottage in Longwood grounds—a small wretched room—the face very handsome, and much like his best prints when First Consul. He had become corpulent and full in the face before death. The change was remarkable." He concludes with these words: " Well would it have been for England if it could be said that during his captivity its greatest enemy had been treated with noble generosity."

Emmett still had a long life before him. He served at Cork, Manchester, Newcastle, Bermuda, Scotland, the Channel Isles, and Malta. When the Crimean War broke out he was suggested by Sir John Burgoyne for the Royal Engineer command in the East, but was obliged to decline, sorely against his will, in consequence of the suffering in his arm, due to the Badajos wound. So he became Commanding Royal Engineer in Ireland, and gained great credit by the construction of the Curragh Camp. It may also be mentioned that in 1840, on his return from Bermuda, Lt.-Col. Emmett had been instructed to " examine and report upon the improvements which had been adopted in Heavy Ordnance, Carriages, etc., with a view to promote those changes in the construction of batteries, embrasures, etc., which might have become necessary," in which he proposed the adoption of a dwarf traversing platform, enabling the gun to fire over a 4 ft. 2 in. parapet, instead of through an embrasure. This proposal was at first rejected by a Select Committee at Woolwich, but two years later was adopted into the Service.

Major General Emmett died and was buried at Brighton in March, 1872.

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Colonel Simeon Hardy Exham, C.B., C.B.E., late R.E.

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MEMOIR.

COLONEL S. H. EXHAM, C.B., C.B.E., LATE ROYAL ENGINEERS.

Colonel Simeon Hardy Exham, who died at Walton House, Felixstowe, on the 26th November last, was a typical example of an Officer of the Corps of Royal Engineers who was called upon to fill many varied positions of heavy responsibility both Military and Civil, and succeeded in all he undertook.

He served under both the War Office and the Admiralty, and latterly, on retirement, he proved how useful the experience and knowledge he had acquired could be in the management of a large estate.

Colonel Exham, who was born at Cork on the 5th July, 1850, was the second son of the late Thomas Exham, of Monkstown, County Cork, and Frances, daughter of the late Simeon Hardy. He joined the R.M.A., Woolwich, in 1869, and obtained a Commission in the R.E. in 1871. After the usual two years at the S.M.E., he went to India, but before embarking, he married Emily, daughter of the late Rev. Godfrey Clarke Smith, of St.Olans, Coachford, Cork, who, after 53 years of an ideal married life, now survives him.

On arrival in India, Exham was posted to the Bengal Sappers and Miners at Roorkee, and remained there until the Afghan War of 1878-79 broke out, when he was Adjutant of the Corps. Exham joined the Khyber Force under Sir Sam. Browne, and was present at the taking of Ali Musjid, receiving the Medal and Clasp.

In 1880, he returned to England, and after two to three years at Cork, he was selected for the highly responsible position of Adjutant at the S.M.E., where, in addition to the ordinary duties of an Infantry Adjutant, he had to keep in touch with, and work in harmony with those responsible for the more technical training of the Corps—not always an easy position. Exham, however, was equal to the task, and the relations between the Barrack Square and the Instructional Staff were more than usually cordial under his adjutancy, his unruffled temper and invariable cheerfulness having much to do with this happy state of affairs. After a term of five years, Fate decided (for Exham was never a pusher of his

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own interests) that he should relinquish the more military side of his profession and become a highly efficient Civil Engineer, his appointment as Assistant Superintending Engineer of the Building Works at the Royal Arsenal, Woolwich, in 1888, being the first step in this direction. After seven years here of very useful work, Exham was transferred to the Works Department of the Admiralty, where he remained until his retirement in 1911.

It was during this period of Admiralty service that Exham made his name as a civil engineer, and more especially in connection with the construction of the great Naval Base at Rosyth. The nature and extent of this vast undertaking was described in considerable detail in a Lecture which he delivered at the S.M.E., and a more general description appeared in the issue of the *East Anglian Daily Times*, of the 1st December last, from which the following is an extract, it also includes a reference to the important works which he carried out when at Portsmouth :

" In 1895 he was lent by the War Office to the Admiralty, and became Superintending Engineer at Portsmouth Dockyard. He carried out there some very important work, lengthening and reconstructing docks and workshops to meet the rapidly changing conditions of naval construction. One of the workshops there, which he designed, is still, we believe, regarded as a model. In 1903, when it was decided to provide a new naval base on the East Coast, Lieut. Col. Exham (he attained that rank in 1896) was sent by the Admiralty to make investigations in the neighbourhood of Rosyth. After spending a considerable time at a village on the coast, from which he made various expeditions, both ashore and afloat, he was able to report favourably as to the suitability of the locality for the purpose, and the Admiralty purchased a large tract of land bordering on the Forth Estuary, where the naval base was to be constructed, and Colonel Exham was entrusted with the work of designing and constructing the naval harbour, and it was built entirely under his direction. He superintended all the local survey work, soundings, etc., to enable the exact site to be determined, and it may be described as having been remarkably successful. The geological formation of the site was very peculiar, consisting of large masses of very soft material with wedges of granite pushing up through it. The planning of the docks and quay walls, in order to get the greatest advantage from the existing conditions, was a matter requiring great skill and knowledge, and the result was a triumph of engineering, which was of enormous benefit to the country.

" It might be mentioned that Colonel Exham was not only in charge of the engineering and dock construction work there, but also of the making of the arrangements with the railway company and with the local authorities for the railway connections, water supply (which had to be brought a very long distance), drainage, and all other civil and social matters. These were naturally of considerable magnitude, being associated with the establishment of a great naval base in a district very

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thinly populated, though adjacent to the large borough of Dunfermline. All these negotiations were successfully carried through, and Colonel Exham won golden opinions from all those with whom he was brought in contact. The great naval base of Rosyth will always be associated with his name. Many of the modern naval docks owe something to Colonel Exham's professional skill and knowledge, available to the Director of Works at the Admiralty during the sixteen years he was in the service of the Admiralty."

The satisfaction of the Admiralty Authorities of the manner in which this great work had been designed and constructed by Colonel Exham was perhaps best expressed in a debate which took place in the House of Commons on the 4th June, 1913, when an attempt was made to obtain a special grant as an acknowledgment of Colonel Exham's exceptional services.

The Rt. Hon. E. G. Pretyman, who was Parliamentary Secretary to the Admiralty at the time in question, supported the case very strongly, and in the course of his remarks said :—

" Then I come to the case of Colonel Exham. He was also an Officer of the Royal Engineers, and entered the Admiralty Service in 1895 as civil engineer. He did admirable work at Portsmouth. He was responsible for the construction of a new naval barrack, for the construction of two new docks, and for the great workshop at Portsmouth, which; I believe, is a model for all the engineering shops in the world. In 1902, the question arose of a new naval base for Rosyth, and Colonel Exham was sent there to examine and report upon a suitable site from an engineering point of view. He reported favourably upon the site, and, in 1903, when it was decided to construct the naval base, he was sent up to Rosyth and placed in charge of the whole of the constructive work, and he personally prepared a design, entirely out of his own brain, from his own observation, and from borings and calculations made upon the spot. The contract drawings were prepared at the Admiralty, but he was solely responsible for the design, which was accepted as it stood. The country does not know what it owes to Colonel Exham. He had to prepare a design for the whole of a great naval base, not for a dock or a basin or a naval barracks, which are large things in themselves, but a design laying out the whole of a great property then acquired for the Admiralty, and laying it out, not only from the point of view of the works which were to be immediately constructed, but from the point of view of the future, to make the very best possible use, both to-day and to-morrow, and in the future, of the whole of that great area for naval purposes, so far as human foresight could do it. I believe that design has given the utmost satisfaction. There is not a soul who has been connected with Rosyth, whether railway managers, representatives of Scottish local authorities, the Board of Admiralty, or anybody else, who had occasion to come into contact with Colonel Exham, who will not bear the highest testimony to the value of his services from every point of view."

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Admiral Lord Charles Beresford also spoke and made several allusions to what he described as "this enormous work," "the creation of Colonel Exham's brain."

An effort was made to retain Colonel Exham's services after he had reached the usual age limit, but it was fruitless, so he retired in 1911, receiving the C.B. as a mark of appreciation. Shortly afterwards he was requested by his old friend, the Rt. Hon. E. G. Pretyman, to assist him in an advisory and administrative capacity in the management of his estate in Suffolk, and the highly useful work he did there is indicated in the following extract from the same notice in the *East Anglian Daily Times*:—

"When Colonel Exham came to reside at Walton, his long friendship with Mr. Pretyman naturally led to the association of the retired engineer with the Felixstowe dock, sea defence works, and other matters connected with the Orwell Estate. He became Consulting Engineer to the dock, and when, shortly after his arrival in the district, the sea began to make inroads on the cliffs between Cobbold's Point and the Golf Links, Colonel Exham undertook the construction of defence works. It was under his direction that the effective sea wall under the cliffs was constructed, and the numerous groynes, which have long since disappeared beneath the accumulated shingle, were put down.

"When Mr. E. Moorsom, the former estate agent, retired, Colonel Exham temporarily took charge of the estate and was responsible for its management for about a year, until Mr. J. Arnold-Foster, the present agent, became available."

At the outbreak of the Great War, in 1914, he at once applied to rejoin the Corps and shortly afterwards was appointed to supervise the construction of a semi-permanent camp at Catterick, this being one of a number of such camps constructed by firms of engineers directly under the War Office. Catterick Camp was specially important, being designed for two complete divisions representing, approximately, the accommodation required for 40,000 men. Some 2,000 separate huts were required, and these, together with the necessary accessories such as Railway Connections, Roads, complete arrangements for Water Supply, Lighting and Drainage, represented a very large and important undertaking. Nevertheless, and in spite of formidable war-time difficulties, the Camp was constructed throughout with remarkable efficiency and freedom from friction, and in an almost incredibly short space of time, reflecting the greatest credit on all concerned. Colonel Exham's share in this achievement was rewarded by the receipt of the C.B.E., an honour which everyone will agree was thoroughly deserved.

Such is the brief summary of a life of usefulness founded upon strength of purpose aided by unvarying tact and good temper,

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combined with much ability and an excellent constitution. A great deal of Colonel Exham's success was due to the manner in which he brought into his public life that kindliness and sympathy which had given him the happiest of homes, the love of his family, and the esteem and affection of all his friends.

We have alluded to his capacity for work and friendship, but he was also a good sportsman, played in the eleven at the R.M.A., and held his own at most other games; he was also a good shot and rider, and a yachtsman of considerable knowledge and experience.

He possessed a fine sense of duty, and gained his distinctions in a characteristically unobtrusive manner.

He has given us an example of a life's work well and truly done, and the Corps, to which he was so proud to belong, will no doubt fully appreciate its high value.

Colonel Exham was buried on the 30th November last, at Walton, his funeral being attended by a large congregation, including representatives of the Admiralty, the District Council, the Port Authorities, the British Legion, and other public bodies, and Societies with which he had been associated, who wished to emphasise the great esteem in which he was held.

This memoir has been compiled by three of Colonel Exham's brother Officers, who belonged to the same batch at the Royal Military Academy, and afterwards at the School of Military Engineering. A fourth Officer of this batch had also expressed a cordial wish to assist, but to our very great regret this Officer, the late Brigadier-General Sir Edward Raban, was too unwell to collaborate. This is the more to be regretted as Sir Edward Raban and Colonel Exham were so long associated together under the Admiralty.

R. M. R.
H. P. L.
N. M. L.

BOOKS.

BRITAIN'S SEA SOLDIERS.

A Record of the Royal Marines during the war, 1914-1919. Compiled by GENERAL SIR H. E. BLUMBERG, K.C.B., Royal Marines. (Devonport, Swiss and Co.)

The Corps has received a presentation copy of this beautiful memorial book of the Royal Marines. It contains 492 pages, is well printed, well illustrated—with a coloured portrait of H.M. The King as a frontispiece—and has seven useful maps in a pocket at the end.

Dealing with the experiences of "Soldier and Sailor too," its contents

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form a resumé of nearly every operation of the war, both by land and sea. Royal Engineer readers will turn with interest to the chapter on the Royal Marine Engineers, whose numbers approached 10,000 at the time of the Armistice. The book has been placed in the R.E. Corps Library at the Horse Guards.

F.E.G.S.

THE WORLD CRISIS, 1916-1918.

Parts I and II. By the RT. HON. WINSTON S. CHURCHILL, C.H., M.P. (Thornton Butterworth, Ltd., 1927). Price 42s. nett.

In these two volumes Mr. Churchill concludes his book on the World War. It will have a very large circulation, and there is a distinct danger that many uninstructed readers, charmed by its literary style, will be led blindly to accept the author's criticisms and deductions without realising the fallacies in his arguments. Both soldiers and sailors must read the book because it contains a great deal of matter on the conduct of war which will be of use to them in their military education. They will have little difficulty in putting their fingers on the weak spots in the arguments on which the author bases his deductions. In military and naval circles the book will cause great resentment, because of the unfair criticism of the leaders on both sides, most of whom will not or cannot defend themselves.

The material for these later volumes, Mr. Churchill tells us, had been collected for some time, but ministerial duties had prevented him working it up. The publication of Sir William Robertson's, "Soldiers and Statesmen," evidently impelled Mr. Churchill to hasten the completion of his own book. If he had waited he might have been able to avail himself of the memoirs not only of the great Staff Officers, Robertson, Falkenhayn, and Ludendorff, but perhaps also of those of the great Commanders, Haig, Joffre, Foch and Pershing. Sir William Robertson's account of the conduct of the war by soldiers and statesmen could not, however, be allowed to pass unchallenged, as it provided Mr. Churchill with a peg on which to hang a scathing indictment of the conduct of the war by the General Staffs, both of the Allies and of the Central Powers. For material as to the conduct of the great commanders, Mr. Churchill has had to content himself with Colonel Boraston's "Sir Douglas Haig's Command," and M. Jean de Pierrefeu's "G.Q.G." One cannot help almost agreeing with Mr. Churchill that Colonel Boraston's book has "done service to everyone except his Chief," and that author can never be forgiven for his unjust and tactless criticism—in a footnote—of the leadership of the Commander of the First French Army in 1918.

Four great controversial subjects are the main features of Mr. Churchill's book. They are :—

1. The Western Front.
2. The Great Offensives.
3. Man-power.
4. Jutland.

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THE BATTLE OF JUTLAND.

Of the battle of Jutland a soldier is not in a position to say much. Mr. Churchill charges Admiral Jellicoe with :—

(*a*). Allowing a quarter of an hour to elapse before passing to the 2nd Battle Squadron Admiral Beatty's signal (sent at 7.47 p.m. on May 31st)—"Submit that the van of the battleships follow me."

(*b*). Failing to realise that the German Fleet was most likely to retreat by way of the Horn Reef and Heligoland Channels, and therefore not directing his course to a point about ten miles to the south-westward of the Horn Reef Light, when he would have been in a favourable position to bring Admiral Scheer to battle, whether he made for the Horn Reef Channel or the Heligoland Channel. Instead of doing this, Admiral Jellicoe, he says, steered to the southward, leaving Admiral Scheer free to retreat by the Horn Reef Channel, the Heligoland Channel, or, if he chose, by the Kattegat, which also he took no steps to watch.

(*c*). Rejecting the Admiralty version (received by him at 11.30 p.m. on 31st May) of the over-read German wireless message—"German Battle Fleet ordered home at 9.14 p.m., Battle Cruisers in rear. Course S.S.E., ¾ E. Speed 16 knots," and continuing to steam southward himself at seventeen knots.

(*d*). Being responsible for there not being a more flexible system of fleet training and manœuvring, and attempting to centralize in a single hand the whole conduct of so vast a fleet.

(*e*). Making no attempt to take advantage of the speed of the fast division of battleships (*Queen Elizabeths*).

(*f*). Not using the British Light Cruiser Squadrons and Flotillas as they ought to have been used to parry and rupture hostile torpedo attacks, and using the merely passive "turn-away" manœuvre of the whole fleet, and thus wasting time and losing distance.

Mr. Churchill claims that the chance of a lifetime was thrown away not once, but three times: at the moment of deployment; an hour later, at 6.55 p.m., when Scheer, after heading westwards for twenty minutes, made his great miscalculation as to the position of the British Battle Fleet, and turned eastward, heading right into the jaws of the British line of battle; and, lastly, when Admiral Jellicoe rejected, at 11.30 p.m., the evidence of the Admiralty wireless as to the direction of the retreat of the German Fleet.

He concludes his indictment tersely with the words: "Three times is a lot."

Though purporting to steer in his account a middle and fair course, Mr. Churchill is writing after the event, and makes no allowance for the fog of war or for the difficulties of communication in a sea battle. He admits that the Naval Commander-in-Chief was the only man who could lose the war in an afternoon, but he minimizes the weight of the responsibility on his shoulders. Mr. Churchill damages his argument by pressing it too far. The Admiral, he says, was given the most powerful fleet that ever sailed the seas. He was refused no demand calculated to increase

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its strength and efficiency. But when offered the chance of a decisive victory he threw it away, not once, but three times, by over caution, inspired chiefly by exaggerated fear of the danger of under-water damage by mine and torpedo. Mr. Churchill asserts that the Battle Fleet was never seriously in action, and that only one battleship, the *Colossus*, was struck by an enemy shell; and that out of more than 20,000 men in the battleships only two were killed and five injured.

Is this a fair indictment? Why have we not held the First Lord of the Admiralty responsible for the defects in the battle cruisers which led to the destruction of the "Queen Mary" and the "Invincible," and of the "Indefatigable," or for the comparative inferiority of our armour-piercing shell? Mr. Churchill discusses these defects, but he does not shoulder the responsibility for their existence in a fleet for the creation of which he was himself responsible. He claims that he never liked the battle-cruiser type, and discouraged their construction, but had not the battleships the same defects in their ammunition hoists? It is possible, though unlikely, that the loss of three battle cruisers may have affected Admiral Jellicoe's plans.

Mr. Churchill's account of the battle is intensely interesting and well told, but it is spoilt by the evident bias and resentment shown in his conclusions. Bias against the Commander-in-Chief; resentment that the child of his own creation should not have achieved the spectacular victory which might have ended the war in 1916.

Joffre, when asked who won the Battle of the Marne, replied that it was a difficult question to answer, but he knew whom the world would say had lost it, if it had been lost.

Mr. Churchill writes on page 30, Part I, as follows:—

> "These chapters will recount the fall from dazzling situations of "many eminent men; and it is perhaps worth while at this point "to place the reader on his guard against unworthy and uncharitable "judgments." The warning is by no means unnecessary.

Mr. Churchill is again "down upon" the sailors, when, on page 350, Part II, he writes:—

> "The shortcomings in the Higher Command of the British Navy, "afloat and at home, which had led to Admiral de Robeck's failure "to force the Dardanelles, to the abortive conclusion of Jutland, and "to the neglect to carry the fighting into the German Bight, had given "to the enemy during 1915 and 1916 the means of developing an "entirely novel form of sea attack upon a scale the potential intensity "of which no one could measure beforehand, and which if successful "would be fatal."

This paragraph serves as introduction to an instructive chapter dealing with the U-boat campaign, and how it was at last overcome by the British Navy and Mercantile Marine. It is interesting to note that Mr. Churchill blames the Admiralty for overestimating the value of the Belgian littoral as a base for the U-boat campaign, and thus causing Sir Douglas Haig to concentrate attention on the offensive in Flanders which resulted in Paschendaele, in 1917. At the same time, in describing the Zeebrugge exploit, he records the fact that the sinkings of British vessels in the English Channel decreased from about 20 a month to 6 a month, and that

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the minefields laid by the Flanders U-boats fell from 32 a month in 1917 to 6 a month in 1918, as a result of Admiral Keyes' tenure of command at Dover.

THE GREAT OFFENSIVES AND THE WESTERN FRONT.

Mr. Churchill takes—and deserves—credit for having appreciated before any other statesman the fact that things had come to a deadlock in the West. He writes as follows :—

" I conceive myself entitled to repeat, now that the results are known, " the opinions which I put on record before all these battles (Loos " and Champagne, Somme, Verdun, Paschendaele and March 21, ' 1918) were fought. I wrote to the Prime Minister on Dec. 29th, " 1914, as follows : ' I think it quite possible that neither side will " have the strength to penetrate the other's lines in the Western " theatre . . . without attempting to take a final view, my impression " is that the position of both armies is not likely to undergo any " decisive change.' "

This was after Mr. Lloyd George's disillusioning visit to Paris, whence he returned in a mood much depressed at the prospect of the war being unlikely to be over in a year. Mr. Churchill continues :—

" And in June, 1915 (after Festubert and the Second Battle of Ypres), " I wrote : ' It is a fair general conclusion that the deadlock in the " West will continue for some time, and the side which risks most to " pierce the lines of the other will put itself at a disadvantage.' "

From this moment Mr. Churchill apparently made up his mind that all offensives on the Western Front were doomed to failure. He elaborates his argument on this thesis at great length in a chapter entitled " The Blood Test," in which he puts forward a mass of figures to prove that every offensive cost the assailants far heavier losses than the armies which were attacked. His deduction is that all the commanders who initiated these great attacks had a very limited conception of the art of war, and he proceeds to show them how it ought to have been done.

He confesses that he " shared the common impression that the German " losses at Verdun must be heavier than those of the French," and it was with surprise he learnt after the war that the French lost 460,000 against 278,000—killed, missing and prisoners. He explains this apparent anomaly as follows :—

" All accounts, however, showed that the strain upon the French " Army was enormous. They were compelled to defend all sorts of " positions, good, bad and indifferent, and to fight every inch of the " ground, with constant counter-attacks, under a merciless artillery ; " and it was clear that they were conducting the defence in the most " profuse manner. 'The French,' I wrote at the time, ' suffered more " than the defence need suffer by their valiant and obstinate retention " of particular positions.' "

Mr. Churchill's recipe for those who are attacked is :—

" Meeting an artillery attack is like catching a cricket ball. Shock " is dissipated by drawing back the hands. A little ' give,' a little " suppleness, and the violence of impact is vastly reduced."

The maxim, *reculer pour mieux sauter*, is not unknown to the French.

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But it postulates the fact that there must be room to fall back, and no reasons why the defender should not do so. Mr. Churchill talks airily about the defender being advised to invite attack by apparently weakening his line in suitable localities, where he can without detriment give up 20 kilometres or so of terrain, and thus draw the enemy on and then blast him to pieces by the fire of an overwhelming artillery concentrated for the purpose.

He considers that there was no real necessity except sentiment to cause the French to cling so obstinately to Verdun. He blames Joffre for their doing so.

Now to turn to the Germans. Mr. Churchill, who apparently has a bias against General Falkenhayn, considers that he went far to lose the war by deciding to attack Verdun. He quotes a memorandum written for the Emperor by Falkenhayn, when he selected Verdun as the point of the German attack in 1916, in which that General wrote as follows :—

> " Moreover the lessons to be deduced from the failure of our enemies' " mass attacks (Loos and Champagne, 1915) are decisive against " their battle methods. An attempt at a mass break-through, even " with an extreme accumulation of men and material, cannot be " regarded as holding out prospects of success against a well-armed " enemy whose morale is sound, and who is not seriously inferior in " numbers. The defender has usually succeeded in closing the gap. " This is easy enough for him if he decides to withdraw voluntarily, " and it is hardly possible to stop him doing so. The salients thus " made, enormously exposed to the effect of flank fire, threaten to " become a mere slaughter-house."

General Falkenhayn goes on to say that there is no sense in attacking any sector where there is no well-defined objective within reasonable reach, without which an attack would be purposeless. What a valuable nugget this extract is for Mr. Churchill! It confirms all his theories. Or, did it give him the idea for those theories? It was written during Christmas, 1915, but was not published till Falkenhayn issued his memoirs after the war—not too late for Mr. Churchill's " after the event " criticisms of the war. He blames Falkenhayn for adhering to the idea of the Verdun offensive in spite of writing this sensible appreciation, and holds that nothing could justify his obstinate adherence to the plan.

General Falkenhayn, after discussing all the alternatives, continues his appreciation as follows :—

> " Within our reach, behind the French section of the Western Front, " there are objectives for the retention of which the French General " Staff would be compelled to throw in every man they have. If " they do so, the forces of France will bleed to death—as there can " be no question of withdrawal—whether we reach our goal or not. " If they do not do so, and we reach our objective, the moral effect " on France will be enormous."

General Falkenhayn appreciated the situation correctly. France was not prepared to give up Verdun. France was not only bled white upon the anvil of Verdun, but the great Allied offensive on the Somme, planned before the attack on Verdun was launched, was not only greatly reduced in extent, but more than compromised in its results. The British lost

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on the Somme 410,000 men as against 180,000 Germans. Was Falkenhayn justified? He certainly was relieved of his appointment as a sop to German disappointment at the failure to capture Verdun, but he was immediately employed again in the Eastern theatre. He was not the bad soldier Mr. Churchill would have us believe.

Mr. Churchill is ungrateful. There is another nugget for him in the memorandum already quoted. In discussing the alternatives before deciding on Verdun as the objective of the German efforts in 1916, General Falkenhayn wrote as follows :—

" In the East, *the rich territory of the Ukraine is the only objective that* " *can be considered.*"

The italics are Mr. Churchill's. His comment on this is :—

" It (*i.e.*, Verdun) involved the complete reversal of the policy by " which General von Falkenhayn had, in 1915, restored the German " situation. Instead of pursuing his advantage against the weaker " antagonists, he selected for the great German effort of 1916 the " strongest enemy at that enemy's strongest point."

Incidentally, Mr. Churchill, elsewhere, goes to some length to show that thanks to the ineptitude of G.Q.G. and its Chief (Joffre) the defences of Verdun were not at all what they should have been when the German attack was launched, and would have been even worse had it not been for the presence in the garrison of a Deputy and Colonel of Chasseurs (Driant) who had the courage to go to Paris and tell the politicians that the defences of Verdun were in a parlous state. Colonel Driant was killed on the third day of the assault, but he will, thanks to Mr. Churchill, go down to posterity as the classic example of the advantage of having soldier politicians serving in the Army. This contingency has, however, been provided for in the new French Defence Act, which lays down that soldier politicians cannot come and go, and if they elect to serve, must continue to do so, and can only vote by proxy.

But to return to the nugget. Mr. Churchill continues :—

" The vital need for Germany was to break the blockade . . . Only " in one direction lay salvation. If she could not break the blockade " by sea, she must break it by land. . . Only in the East and South- " East and in Asia could Germany find the feeding grounds and " breathing room—nay, the man-power—without which her military " strength, however impressive, was but a wasting security. . . The " true and, indeed, the only attainable political objectives open to " Germany in 1916 were the final overthrow of Russia and the " winning of Roumania to the side of the Central Empires. . . . " Roumania was essential to Germany. . . A sagacious German " policy at this juncture could have offered to Roumania in combina- " tion every inducement to join her neighbours, from high rewards " to extreme duress. . . The skilful employment of fifteen or twenty " German Divisions animating Austrian and Turkish Armies would " surely and easily have extended the territories which nourished " Germany so as to include, by the end of the summer of 1916, the " whole of S.E. Europe, the Black Sea, the Caucasus, and the Caspian. " The Austro-German front against Russia might have stretched " from Riga to Astrakhan. . . At every moment, and at every stage

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" in these vast combinations the pressure upon Russia and upon " her failing armies would have increased, and at every stage her " troops and those of her allies would have been dissipated in vain " attempts to wall in the ever-spreading flood in the East, or *would* " *have been mown down in frantic assaults upon the German trenches in* " *France.*" The last italics are not Mr. Churchill's. The sentence was an afterthought. He suddenly awoke from his dream.

What an opportunity for the Allies! What a gift to the idiots headed by Joffre who thought a decisive victory could only be achieved on the Western Front!

But was Russia in such a plight in early 1916 as Mr. Churchill made out? On page 104, Part I, he writes:—

" Few episodes of the Great War are more impressive than the " resuscitation, re-equipment and renewed giant effort of Russia " in 1916,"

which culminated in Brusiloff's offensive on June 4th, and resulted in Austria losing 100,000 prisoners in a week and a loss of nearly 750,000 men in killed, wounded, dispersed and prisoners within a month. And this, it should be noted, as the result of a great *offensive* movement on the part of the Russians. Mr. Churchill attributes the Russian success to the surprise caused by their ante dating their offensive from July 1st to June 4th.

Enough has been said to show that Mr. Churchill's book is apt to mislead. That even during the war the author of this book had brilliant ideas is not disputed. Antwerp in 1914, the Dardanelles in 1915, an Allied offensive in the Balkan Peninsula in 1916, coupled with a decisive victory in the North Sea in that year might have brought the war to an end in 1917. BUT—and the word must be spelt in capital letters—there are many factors to be considered in every appreciation, and Mr. Churchill has only learned to weigh all the factors after the events have been decided.

The writer was invited to undertake this review " as there seems to be so much in it that is at variance with the conclusions of Sir William Robertson." In his opinion, Sir William Robertson has done the nation an immense service in publishing "Soldiers and Statesmen," and that service has been enormously enhanced by the appearance of Mr. Churchill's book. Sir William Robertson's conclusions are not impaired by it. The Memoirs of General Falkenhayn and Ludendorff show that both those great minds were at one with Sir William Robertson as to the Western Front being the decisive one, and events prove the correctness of their judgment. Mr. Churchill considers that General Ludendorff lost the war by attacking in March and April, 1918. The war was lost by the moral effect on the Germans of the tenacity of the Allied Armies on the Western Front, by the effect of the blockade which was the result of British Sea Power, and by the magnificent courage of the soldiers who carried out the offensive campaign of the autumn of 1918, in spite of Mr. Churchill's prognostications, of which, fortunately, they were not aware, that no offensive on the Western Front could be successful till 1919.

In 1919, thanks to Mr. Churchill's activities—and they were in truth

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great—at the Ministry of Munitions, and thanks to the arrival of the Americans in their millions, the politicians intended to allow the Allied Commanders to launch an offensive on the Western Front, with subsidiary offensives elsewhere, amongst others an attack aimed at Constantinople, *via* the Dardanelles.

MAN-POWER.

We now come to the question of man-power. It is almost inconceivable, but Mr. Churchill is our authority, that the reason why large numbers of men (Mr. Churchill estimates the number at 1,400,000) were kept back in England, Scotland and Ireland during the winter of 1917-18, was that the Statesmen could only be sure of not being stampeded into another Allied offensive on the Western Front by withholding the drafts necessary to maintain the British Armies in France. Brigades of Infantry were reduced from 4 to 3 Battalions, Cavalry Divisions were reduced, and practically no units were at anything approaching their war establishments. This, in spite of the certainty, for such it was, thanks to our admirable Intelligence, that the Germans were transferring the troops released by the Russian *débâcle* from the Eastern to the Western Front as fast as trains could be got together to carry them. The writer can remember the late Sir Henry Wilson thanking Heaven that the German attack came in March and not in May, 1918, by which time the transfer of troops and guns would have been still more complete.

Mr. Churchill admits that

> "Sir Douglas Haig vehemently and naturally called for all the "officers and men required to bring his divisions up to full strength "at the earliest possible moment. Robertson supported him, and "was evidently seriously alarmed. From my central position "between the Army and the War Cabinet, with, I believe, the whole "information available in my possession and with constant access "to the Prime Minister, I never ceased to press for the immediate "reinforcement of Sir Douglas Haig. Mr. Lloyd George viewed "with horror the task imposed on him of driving to the shambles by "stern laws the remaining manhood of the nation. . . . . "To meet the German onslaught when it came—if it came—every-"thing must be thrown in: but the Prime Minister feared lest our "last resources should be expended in another Paschendaele. . . . "I urged that the Cabinet should send all the men that were needed "and reconstitute the Army, and should at the same time forbid "absolutely every resumption of the offensive. The Prime Minister, "however, did not feel that, if the troops were once in France, he "would be strong enough to resist those military pressures for an "offensive which had so often overborne the wiser judgment of "Statesmen. He therefore held, with all his potent influence, to a "different policy. He sanctioned only a moderate reinforcement "of the Army, while at the same time gathering in England the "largest possible numbers of reserves. In this way he believed he "would be able alike to prevent a British offensive and to feed the "armies during the whole course of the fearful year which was "approaching (1918). This was in fact achieved. But I held, and

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"hold still, that the War Cabinet should have been resolute, as I "believe it would have been found strong enough, at once to support "and to restrain the High Command in France."

Mr. Churchill goes on to quote in full a memorandum written by him on December 8th, 1917, in which he shows that he, at all events, realized how unfair it was to Sir Douglas Haig to withold the reinforcements, and how it might prevent the Commander-in-Chief taking advantage of an opportunity, should one offer, to strike a counter blow, or even maintaining the "active-defensive", of which Mr. Churchill makes so much in his book—as preferable to the offensive when a prolonged offensive is not justified or is impossible.

He also states that nearly all the specific measures which he advised for combing out more men, especially those employed on naval munitions and shipbuilding, subjects on which he was in a position to be well-informed, were taken or resolved on after the catastrophe of March 21st.

"Taken in January," he says, "they would have prevented it. . .
"Nothing, however, had the slightest effect. The Prime Minister
"and his colleagues in the War Cabinet were adamant. . . They
"believed that the Germans if they attacked would encounter the
"same difficulties as had so long baffled us, and that our armies
"were amply strong enough for defence."

Does Mr. Churchill realise that his teachings now recoiled on his own head? It was he who had time and again inveighed against the idea that an offensive could be successful on the Western Front. He had been mistaken as to the enormous losses of the French in defence at Verdun—which speaks well for French propaganda—it is to be hoped that the Germans were equally deceived as to the losses they had inflicted.

Mr. Churchill has done a great service in showing us where the responsibility for the destruction of the Fifth Army really lies, and he is to be congratulated on being the first wholeheartedly to absolve Sir Hubert Gough of all responsibility for that disaster. But it is too late. May we hope that if ever again the British Nation is called upon to fight for its existence, British Statesmen will take a leaf out of the American book and not hesitate to synchronize "Registration Day" with the Declaration of War, if the principle of universal service is not adopted in time of peace. The Americans learnt their lesson from their own previous experience and our recruiting difficulties, after the Republic had been in existence close on a century-and-a-half. Surely it is more than time for us to learn the lesson ourselves from our own history.

Mr. Churchill has a good deal to say on the Salonika Campaign, and does not hesitate to pillory Mr. Lloyd George and M. Briand for persevering with it after nearly all the advantages to be gained from it had disappeared; and there are illuminating chapters on the "Roumanian Disaster," "General Nivelle's Experiment," "The Ministry of Munitions," "The Surprise of the Chemin des Dames," "The Unfought Campaign" (of 1919), and "The Teutonic Collapse."

There are some sketch maps, but the absence of a general map is to be regretted. The index, though condensed, is sufficient for the general

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reader. The spelling of M. Clemenceau's name with an accent on the first " e " is incorrect, but is also to be found in Colonel Boraston's book " Sir Douglas Haig's Command."

H.B-W.

GOVERNMENTS AND WAR.

A study of the conduct of war, by MAJOR-GENERAL SIR F. MAURICE, K.C M.G., C.B. (William Heinemann, Ltd., London, 1926).

The volume is based on a course of lectures recently delivered by the author before the University of Cambridge, of which he is Honorary LL.D.

For his subject Sir Frederick Maurice chose the relations which existed between statesmen and soldiers during the course of a long war, and as an historical example he selected the Civil War in the United States, 1861-5.

For the choice of subject and campaign, the author gives the following reasons :—

(1). He had realized that, although before the Great War he had thought and read much about the organisation of armies for war, he had never thought of studying the organization of Governments for war.

(2). A similarity exists between the two struggles, not only in their duration, but also in the fact that one of the belligerents occupied a central position and was exposed to the rigours of blockade, and that in both cases there were several theatres of war where co-ordination of effort was difficult but yet urgently needed.

(3). He believed that the judgments of Lord Wolseley (whose biography he has written), and of Colonel G. F. R. Henderson on President Lincoln's conduct of the war were written on one-sided and incomplete information, and that further investigation would modify the views hitherto held in England as to the action of the great statesman.

(4). In both wars great democracies were involved, and he wished to test the accuracy of the dictum that modern democracy can neither prevent war nor wage it, save at undue cost.

Sir F. Maurice disposes of the last point first, and comes to the conclusion that it would appear to be at least possible that mistakes in the conduct of war are not necessarily the consequence of any particular form of Government, but they may be due to causes which are remediable whether the form of Government be an autocracy, a constitutional monarchy, or a republic.

In discussing the relations between Mr. Jefferson Davis, President of the Southern Confederacy, and his generals, Robert E. Lee and J. E. Johnston, he shows Davis to have been a man of by no means outstanding ability, but he considers him to have been above the average of war ministers. Davis' early training at West Point and afterwards as a young officer in the cavalry, his subsequent political career and the experience he gained while Secretary of War in the United States from 1853 to 1857, gave him an immense advantage over his famous opponent,

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Abraham Lincoln, who had little or no experience of general affairs and none of military affairs. He shows how Davis failed in the general direction of military operations, in combining policy and strategy, and that he failed because he had never worked out in his mind a system for the conduct of war. Going on to discuss the relations between Davis and General J. E. Johnston, he considers that Johnston, who disliked Davis and despised him (he had known him at West Point), was in great measure to blame for the friction that existed between them. He never confided his plans to the President and consequently never won his confidence.

How different were the relations between Davis and General Robert E. Lee: "Lee's dealings with the President were a very marked contrast. Lee appreciated to a nicety the relations which ought to exist between himself and the head of the State. He invariably treated the President with the most complete courtesy and respect, gave him all necessary information, and being himself entirely devoid of personal ambition or of any trace of self-seeking, he never aroused in his chief, who was inclined to be both arrogant and jealous, the faintest suspicion that he coveted powers which should belong to the President. He was often tried by Davis every whit as highly as Johnston had been, but through all these trials he shewed a remarkable understanding of the President's difficulties and problems, and he continued quietly and tactfully to educate him in the principles of strategy and of the conduct of war."

Davis was undoubtedly good on the administrative side, thanks to his experience in an Indian campaign, in the Mexican war, and in the War Department, but it was a case of a little knowledge being a dangerous thing when he meddled in operations.

Despite the good relations which existed between Davis and Lee, the policy of the two men was never really in agreement. Davis' only policy was to defend Southern territory and play for foreign intervention. All hope of the latter was wiped out by Lincoln's declaration for the abolition of slavery. Davis could not steel himself to withstand the incessant appeals to him for protection which came from all parts of the Confederacy, or to overcome the reluctance of the several States to denude themselves of troops. This was mainly because he was not so constituted as to be able to take great risks for great ends.

"Lee's policy was clear from the first. He saw that the salvation of the South lay in early victory before the North had time to develop its resources, and he was prepared to dare much to bring this about. In Davis' mind the risks always loomed greater than the promise of success, so that not even in the high tide of Lee's success was there any real union of Confederate policy and strategy, the chief reason for this being that there was no one in Richmond to advise the President on the military problem as a whole."

When Lee took command of the army in the field, he could not induce Davis till too late to fill the place which he had occupied as military adviser, and his own extreme modesty and reluctance to push himself forward prevented him from asking for increased authority and powers for himself. Davis was eager to give Lee greater powers, but did not know how to set about it. The result was that when, after the victory of Chancellorsville in 1863, Lee advised the immediate invasion

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of Pennsylvania, so that by a victorious advance the growing peace party in the North might be encouraged to insist on peace, Davis failed to realize that this was the Confederacy's last chance and did not give Lee the reinforcements and support which the army of Northern Virginia might have received if there had been a man at Richmond who was prepared to take risks elsewhere in order that by invasion peace might be won. Torn between two fronts, Davis was defeated on both. Was it more important to preserve Vicksburg against Grant's advance in the west than to save Richmond from danger? The President's confidence in Lee made him approve the plan for the invasion of Pennsylvania, but he could not see further than that it would result in the threat on Richmond being removed. Instead of "going all out" to ensure the success of Lee's advance by sending him every possible man and gun, which alone would justify him in crossing the Potomac, he failed to re-inforce and re-equip his army. The result was Gettysburg, and Lee's retreat. Vicksburg was also lost, and, although the struggle went on for nearly two years longer, the last hope of victory had been shattered.

"Never again after the summer of 1863 were there opportunities which a skilful combination of statecraft and strategy could use to save the Confederacy from its fate. The greatest soldier of modern times could not do more than win victories in the field. He needed, in the circumstances of the time, the aid of a great statesman to make victory decisive, and the great statesman was in Washington, not in Richmond.

"But, it may reasonably be asked, if a great statesmen is the necessary complement of a great soldier, how can any nation reasonably expect to have both when a crisis comes? The answer is that we to-day are not living in the circumstances of 1863. We have had, and may learn from, experiences, which Davis had not.

"A reasonable competence in statesmen and soldiers is not sufficient to prevent disaster. Every war of importance in which Great Britain has been engaged since 1756 has begun unfortunately. Our troubles, like those of Davis, arose far more because we had evolved no system for the conduct of war than because of any exceptional lack of capacity in our statesmen. It requires an Abraham Lincoln to devise in the stress of war a sound system for its conduct when none has been prepared beforehand. But a Davis is well capable of administering the affairs of a nation at war, when that nation has considered in time the respective functions of statesman and soldier."

The author then describes the relations of President Lincoln and General McClellan. Lincoln had made McClellan commander-in-chief after the resignation of General Scott. McClellan was undoubtedly a good soldier. General Grant, after the war, declared:—"If McClellan had gone into war as Sherman, Thomas or Meade, and had fought his way along and up, I have no reason to suppose he would not have won as high distinction as any of us." He had real gifts of organisation and leadership, and was quickly not only respected but loved by his men. Attractive in manner and appearance, young—only thirty-nine—everyone from the President downwards was anxious to serve and help him. But

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appointment to the highest command seems to have turned his head. "He was lacking in the elements of courtesy to the President, of whom the best he could say was 'he is honest and means well.' After the first enthusiasm for him had cooled there was a good deal of political intriguing against him, and McClellan, finding the difficulties, which he had himself in great measure created, becoming too much for him, classed, in his anger, all the administration in Washington as unscrupulous and false."

Though McClellan had only himself to blame for the first fall from grace, it was the Government which was responsible for the next false step. The ill-managed affair at Ball's Bluff on October 21, 1861, ended in a disastrous repulse of the Federals, and as a result a Congressional Committee of enquiry was instituted, which developed into a committee on the conduct of war. Its proceedings were often injudicious, and they were periodically a thorn in Lincoln's side. Two of its principal members were hostile to McClellan, and thought Lincoln was wanting in energy in the conduct of the war. Great pressure was brought on the President for some definite military action. At first Lincoln, remembering Bull's Run, resisted the pressure and told McClellan not to fight till he was ready. But eventually yielding to the pressure, Lincoln did a very foolish thing. He assumed his power as Commander-in-Chief, and in that capacity issued three orders, in which he not only specified the date (Washington's birthday, February 22, 1861), for a general advance, but also defined the objective (Manassas Junction), and stipulated that at no time was the security of Washington (the capital) to be jeopardised.

"Lincoln was quite right to issue instructions to McClellan, but it is clear that none of the orders, except perhaps the third, was intended to be an instruction as to military policy. They were meant to rouse McClellan to action. They probably made him laugh (or swear!)." Two years later Lincoln explained to Grant that he was forced by public opinion to issue the orders because of the procrastination of his commanders. He said that "he did not know but they were all wrong, and did know that some of them were."

In his first chapter the author discusses the question of what system for the conduct of war is best suited to the Constitution of Great Britain and points out that the system adopted when Sir William Robertson became Chief of the Imperial General Staff in 1915 was very similar to that established by Lincoln in 1864.

The book, though, published first should be read as a sequel to Sir William Robertson's "Soldiers and Statesmen."

H. B.-W.

IMPERIAL DEFENCE.

By S. KING-HALL: (Fisher Unwin, Ltd.)

Admiral King-Hall's "Imperial Defence" has been written in vivid but simple style to appeal to the man in the street and to place before the ordinary tax-payer an outline of the problems that arise in considering the defence of our far-flung Empire, and which are the causes of military

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unreadiness and thereby waste of time as well as of public expenditure. It aims at securing the formation of an efficient Empire staff, which may think upon the same lines so as to ensure readiness in our scattered formations at the smallest cost. It reminds the public that sailors and soldiers are taxpayers too, and that it is in the fighting services that the need for squeezing every drop of value out of their several budget allotments is most fully realised. That the armed forces of the nation will more and more become the prime mover that controls the huge national war machine, and will gradually cease to be the machine itself, as they were when war was a simple matter between groups of professionals. Indeed, they tend to be but the skirmishers behind whose protection the mass of citizens may gird themselves in security for the coming fray.

There is no parallel in the world, nor has there ever been in history, to the situation in which seven separate cabinets, involving about a hundred cabinet ministers scattered round the globe, have first to sanction a declaration of war with all its tremendous consequences, and then assume joint responsibility for its conduct. Some loss of time can hardly be avoided, and this delay in starting will tend to increase as civilization progresses and war becomes more complicated, unless very definite steps are taken to prevent it.

It is manifestly unfair for the Dominions to claim rights and powers without responsibility, and attention is drawn to the intricate problem of how to ensure that the Dominion cabinets shall share that responsibility with the British cabinet. "If there is one department of Imperial Defence in which it is easiest to make false economies, it is in the department of thought. Trained intelligencies are required to control the fighting services. In order to make sound plans in good time a body of men with highly trained intelligencies are necessary, who can devote their whole time to working out the details of the organization of the Empire for defence." The foundation of a national war college is one of the author's suggestions, to produce a common doctrine on the lines of the tag that "it is better to all think wrong than all think differently." This has already materialised in the guise of the Imperial Defence College which is in session, with students from each of the services, civil departments, the Dominions and India.

"It is quite clear that the executive government must retain, in the conduct of military affairs during a war, the supremacy with which it is invested by the constitution. Indeed, apart from constitutional principles, a soldier, however capable a military leader or responsible a military adviser he may be, is not qualified by his training to steer the ship of state through the troubled waters of war! It is just as dangerous for a Prime Minister or President to assume the actual command of the forces of a nation in action. His duties lie in another sphere which needs complete mental detachment from the commotion of hostilities. We are not yet ready for a Ministry of Defence; a political solvent has yet to be found for all the difficulties involved. It will be discovered only when the nation and its fighting services are of the same mind, through mutual education." The book under review constitutes a primer for thoughtful taxpayers.

The author suggests that all fighting services must have the common aim.

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of furthering the Government policy through a joint service opinion, and, as a preliminary step to such unity of purpose, that the funds allocated to Imperial Defence and the Fighting Services in the budget of the United Kingdom be treated by the Cabinet as a single item, and that the division of the money amongst those services be decided by the Chief of Staffs' Committee.

Thus may true unity be born.

The book is a lucid and engaging one and should be read by every citizen.

D.M.F.H.

TACTICAL SCHEMES.

From Platoons to Brigades, with solutions and notes. By LT-COL. A. KEARSEY, D.S.O., O.B.E., *p.s.c.* (Gale and Polden, Aldershot). Price 7s. 6d.

In the preface to this book it is stated that the author is working progressively through the principles of war to show how they are illustrated in schemes. The author did not carry this into effect : the principles of war are seldom mentioned and no attempt is made to show which principles are best illustrated by any scheme.

Instead, the book consists of a series of chapters dealing with types of military operations, such as appreciations, orders, attack, defence, etc. Each chapter gives one or more schemes dealing with its subject, interspersed with notes and problems which are often inapposite. For instance, in the chapter on Appreciations appears an operation order for the march of a brigade with bus and march tables, while in that on Orders is a lecture on Desert Warfare and notes on the siting and design of trenches.

In the schemes, the lesson to be taught is not given prominence—with the result that the solutions are in many cases vague and run counter to the teaching of the regulations.

The book has another fault which is serious in view of the class of reader for which it is intended. There are many inaccuracies in detail, especially with reference to the R.E. and their work. The examples of orders and messages contain many mistakes, both in spirit and in letter. While this will be obvious to anyone who reads carefully the official manuals, it is very much to be regretted that a book on tactics should be issued which is so very much out of date.

The book cannot be recommended to students except in so far as it gives examples of what should not be done.

N.W.N.-C.

ORDINARY DIFFERENTIAL EQUATIONS.

By E. L. INCE. Professor of Pure Mathematics in the Egyptian University. (Longmans, Green and Co., 39, Paternoster Row, E.C.4). Price 36s.

This is an advanced treatise on ordinary differential equations, that is, on those equations containing but one dependent and one indepen-

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dent variable. During the last 25 years this subject has not received much attention in this country, and Professor Ince has been at great trouble to make known the numerous important contributions made by continental mathematicians during this period.

Quite 50 years ago it was recognized that progress in solving differential equations had reached a limit, and that without new conceptions further advance was impossible.

The required enlarged outlook was made possible by the inception of the Function Theory by Cauchy in France and Riemaine in Germany, and it was seen that although an equation might not be capable of solution in the ordinary sense, it might nevertheless suffice for defining some new function; from this point of view the theory of differential equations in its higher branches becomes an integral part of Function Theory.

The modern theory of Differential Equations is founded on Lie's theory of transformation groups, and on that of the functions of a complex variable.

Professor Ince's book of nearly 600 pages comprises 2 parts.

Part I. Equations in the real domain.

Part II. Equations in the complex domain.

In the first part, classical methods of solution are dealt with, the difficult question as to whether and under what circumstances an equation has a solution is fully discussed, and Lie's theory explained; this theory is analagous to the Galois theory of algerbaic equations. It will thus be seen that Professor Ince has taken full account of recent developments; his treatise is probably the most up-to-date work on ordinary differential equations extant, and is well worth study by a student specializing in the subject. Part I is not very difficult reading, and would be intelligible to anyone who has a fair knowledge of the subject, but Part II requires tolerably advanced knowledge of the Function Theory.

There is an historical summary, from which it appears that Newton was able to solve $\frac{dy}{dx} = 2 + 3x - 2y + x^2 + x^2y$; this he did by assuming $y = A_0 + A_1x + A_2x^2$ *ad inf.*, where the A's are to be found. This is, I believe, the first example of the method of solution by infinite series, a method often the only one possible, and which has led to the discovery of the Bessil and Legendre Functions.

J. M. WADE, Lt.-Col., B.Sc., LONDON.

PRACTICAL PHYSICS.

By T. G. BEDFORD, M.A., F.INST.P. (Longmans, Green & Co., Ltd.). Price 10s. 6d.

The Course of Practical Physics described is based upon the experiments provided in recent years for students, mostly in their first year at Cambridge, as part of their preparation for Part I of the Natural Sciences Tripos.

After a short introduction, dealing with observation and recording results, the book is divided into five Parts:

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I. Mechanics and Properties of Matter.
II. Heat.
III. Light.
IV. Sound.
V. Magnetism and Electricity.

Considerations of space forbid the discussion in detail of theoretical principles in a book on general Practical Physics, but explanatory matter has been given where it was thought it might be found useful.

The apparatus described is that used in the Cavendish Laboratory, Cambridge, but most of it is of a simple kind, so that the experiments can be carried out in most laboratories.

The book is intended to supplement, and not to replace oral instruction.

The aims of the author have been attained by the production of this very good laboratory text-book, with its very clear explanations of the experiments carried out.

R.M.

MECHANICS APPLIED TO ENGINEERING.

By JOHN GOODMAN, WH.SCH., M.INST.C.E. (Longmans, Green & Co., Ltd). Vol. I., Ninth Edition. Price 14s. 6d. Vol. II. Price 16s.

This book has been specially written for Engineers and Students who already possess a fair knowledge of Elementary Mathematics, with the intention of assisting them to apply their knowledge to practical engineering problems. The mode of treatment of the subject is to employ simple, straightforward and easily remembered methods, as far as possible, using elementary calculus sparingly.

The introductory chapter deals with units, velocity, acceleration, work, energy and vectors. The book then takes up the subject of mensuration, followed by that of moments, which is made to include centres of gravity, moments of inertia and radii of gyration, all of which are clearly explained from first principles. A short chapter on composition and resolution of forces, followed by one on mechanisms, leads up to a detailed discussion of the dynamics of the steam engine.

Vibration and gyroscopic action are dealt with briefly, and the subjects of friction and lubrication, with their effects on machine design, are gone into thoroughly. This concludes the dynamics section of the book. The next chapters deal with stress, strain, elasticity, beams, bending moments, shearing forces, deflection, struts, and torsion, and lead up in clear and natural sequence to structures.

The last portion of the book is concerned with hydraulics and pumps.

The Appendix gives useful hints about accuracy in measurements and calculations, and a table of the differential coefficients and integrals commonly met with. At the end of Volume I are a number of examples, with the answers.

Volume II consists mainly of fully worked out examples on all the topics dealt with in Volume I, with frequent cross references.

Both volumes are very fully illustrated and clearly printed.

The author has succeeded in the very difficult task of compiling, in two

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volumes of reasonable size, a useful text book and reference book for all who have to deal with mechanical and instructional engineering, and has mentioned other works to be consulted for fuller information on the various subjects.

R.M.

"COLAS" ROADS.

Asphalt, *i.e.*, bitumen and stone, has long been recognized as one of the ideal road materials; but the drawbacks to its use have been its cost, and the necessity of applying it hot in fine weather.

The discovery of a means of emulsifying bitumen—of which Colas Products, Ltd., claim to be the pioneers—thereby allowing of its application cold in a diluted form, has reduced these difficulties, and the results are apparent in a steadily increasing use of bitumen in road construction.

Bitumen in itself has greater binding powers than tar, owing to its higher ductility and long life, and has a further advantage in its homogeneity and absence of chemical compounds such as phenol, cresol, etc., which are liable to contaminate neighbouring streams.

The purpose of bitumen in modern road construction and the relationship between binder and aggregate are dealt with at some length in the first four chapters of "Colas Roads," and details are given of the different methods required for Colas grouting, surface dressing, and re-conditioning roads; the booklet concluding with various specifications for these processes, and with analyses of cost.

It must be admitted that Colas itself is more expensive than tar, but its application requires little skill, and is independent of weather conditions. In fact, its use is favoured rather than hindered by rain. It is claimed that it more than repays for itself by the greater durability imparted to the road, and the steadily expanding use of this material by various Road Authorities would appear to bear this out fully.

Although the use of Colas for military roads can only be of limited extent, it would appear well worthy of consideration in those cases where gravel or water-bound macadam roads still exist.

In almost every case such roads have to carry far heavier loads than they are fitted for, and semi-grouting or surfacing with Colas might save, or at any rate postpone, for some considerable time, the necessity for complete reconstruction.

The author of this booklet is BRIG. GENERAL E. G. WACE, C.B., D.S.O. late of the Corps of Royal Engineers, and now General Manager of Colas Products, Limited.

G.B.O.T.

SOME BOOKS ON HEATING.

ALTHOUGH fire was probably one of the first discoveries of prehistoric man, the scientific study of the use of heat for all domestic purposes has only developed in the last few years.

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In this country a special study of the subject is being undertaken by the Fuel Research Board, which works under the Department of Scientific and Industrial Research. Their annual report for 1925, which contains an account of their work up to July, 1926, has just been issued. It is mainly devoted to experiments on fuel, including a special chapter on "Low Temperature Carbonisation." The details of experiments on domestic heating are described in technical papers, of which No. 12 on "The Heating of Rooms," and No. 13 on "The Domestic Grate," are especially interesting. These record the result of experiments carried out by Dr. Margaret Fishenden, D.Sc., who has been engaged on such work for many years. The paper on "The Heating of Rooms" deals in some detail with the conditions necessary for the "Warmth Comfort" of man. The report begins by a study of the Heat Production of the human body; then considers the loss of heat under various conditions of environment and the different apparatus in use for producing heat. It ends with a detailed comparison of the cost of different methods of heating, mainly considered from the point of view of the production of the maximum heating by radiation.

The paper on "The Domestic Grate" gives a detailed examination of the various types of grate in use and contains much valuable information as to the points to be looked to when selecting a fitting for a model building.

In addition to these special reports, Dr. Fishenden has published in 1925, under the title of "House Heating," a book which is a complete text book of the development of Heating and Cooking apparatus in this country. It commences with a chapter on fuels, describes the growth of the modern sitting-room grate and the kitchen range, and then deals with the use of gas for heating purposes, showing that all modern forms are based on the Bunsen burner. Electrical apparatus are rather shortly dealt with, and a short chapter is given to Central Heating. This is the least satisfactory feature of a book which is full of useful detail and should be studied by everyone interested in house design.

As a contrast to the English method of approaching the subject, a book has just been published in New York under the title of "Warm Air Furnace Heating," by A. M. Daniels, which promises to become a text book on its own branch of the subject. Although heating by warm air has been in use in America for many years, the modern scientific investigation of heating apparatus and their application to buildings only dates from 1914, when the "National Warm Air Heating and Ventilation Association" was formed by the furnace manufacturers of America. In 1923, this Association erected, at a cost of £5,000 ($25,000), a special test-house for the investigation of problems connected with warm-air heating under actual home conditions.

Mr. Daniels embodies in his book the latest results obtained from these experiments. The larger part of the book is devoted naturally to details of the Piped system which is so largely used in America, but there are useful chapters on Heat Losses (Chap. V.), Chimneys and flues (Chap. XII), Humidity (Chap. XIII), which are applicable to all systems. There are also good chapters on the One-Pipe or Pipeless System (Chap. XVII)

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and on "Forced Air Furnace Heating" (Chap XXI), the latter being specially applicable to large workshops, and similar buildings.

All the above publications can be obtained from the R.E. Corps Library in London.

W.B.B.

MAGAZINES.

REVUE MILITAIRE FRANCAISE.

October, 1926.—The third instalment of Commandant Janet's "*Action d'une division encadrée dans une offensive d'ensemble*" deals mainly with the crossing of the Oise-Aisne Canal, and of the Ailette, on August 29th, 1926. This operation, which was part of a general offensive by the Tenth Army in the direction of Laon, was executed with the greatest difficulty against determined opposition. The crossing of a broad unfordable canal in the face of an active enemy is bound to be a most hazardous undertaking; and the description of the difficulties encountered, especially by the engineers, and of the manner in which they were surmounted, is well worth reading.

Evolution des idées sur l'emploi tactique de l'organisation du terrain, de Napoléon à nos jours, by Lieutenant-Colonel Baills, is written *à propos* of a recent provisional manual on the organisation of field defences. The author, who is a professor at the "*Ecole du Génie*," considers that few French officers have paid any attention to this manual, because they consider either that their war experience is sufficient, or that the higher staffs only require a very general grasp of the subject. Both these ideas are fallacious, and the object of the article is to show that the new manual is based upon Napoleon's principles of defensive action, and that many subsequent failures have been due to neglect of these principles. The remainder of this instalment is devoted to an analysis of Napoleon's orders and writings, showing clearly the importance he attributed to sound defensive organisation.

General O. Boian, the author of *L'événement d'Agasu*, commanded the 14th Roumanian Brigade in an action described in an article entitled "*Une opération de guerre de Montagne*," which appeared in the February number of the *Revue Militaire Française*. An account has also appeared in an Austrian journal, and General Boian wishes to emphasize the importance of this action while acknowledging the accuracy of the two accounts. He gives his preparations and orders in some detail, but the sketch map illustrating them is too inadequate to be of any value.

Commandant Janssen begins an important article, entitled "*La manœuvre en automobile*," in this number. He discusses the size of a column consisting of a mechanicalised division and the measures necessary for its protection. Some of his conclusions, which appear perfectly sound and logical, provide considerable food for thought, especially with regard to the duties of the various protective detachments which will be essential owing to the vulnerability of the main column. The

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writer accepts the principle of transport of a certain number of horses by lorry, though this appears open to dispute after the experiences of our own manœuvres, and he is firmly of the opinion that the one- or two-man tank will become an essential weapon of reconnaissance.

"*Un homme est tout!*" by Commandant Cotard, is an expansion of Napoleon's statement that "In war men are nothing; a man is everything," based chiefly on Napoleon's successes with badly-clothed and fed armies, compared with the failures of inefficient commanders of well-trained and equipped forces.

November, 1926.—The final operation of the 48th Division, described in the last instalment of Commandant Janet's "*Action d'une division encadrée dans une offensive d'ensemble*," was an unsuccessful attack on the Basse-Forêt de Coucy. The author then gives his final conclusions, the most interesting of which are:—

(1). The need for dealing with the enemy's covering and main positions in separate operations. The failure to observe this principle caused the German defeat by General Gouraud's Army in Champagne in July, 1918.

(2). The need for intensive artillery support with gas-shell when attacking a wooded position such as the Forêt de Coucy.

(3). The need for improvement of communications and the long time to be allowed for orders to reach the troops.

"*Organization d' ensemble des communications et ravitaillements dans une armée*," by Colonel Lemoine, is a detailed study of the general reception of supplies and stores at rail-heads and their distribution in the army area. Having described fully the various conditions on which the rail and road systems of transport are organised, Colonel Lemoine then goes on to apply these systems to the various types of operation. The whole article is a very detailed analysis of a most important subject.

Commandant Cotard completes his article, "*Un homme est tout!*" with a discussion of the qualities required by a great commander, illustrated by quotations from the writings of Napoleon and from examples in military history. The only flaw in the writer's arguments to prove that the Commander is all-important appears from the fact that he does not cite a single example of the greatest war in history to support his theory.

In the second instalment of "*Evolution des idées sur l'emploi tactique de l'organisation du terrain de Napoléon à nos jours*" Colonel Bailly describes how, since Napoleon's days, the French Army passed through the stage of passive defence of the 1870 war, to the unrestrained offensive of 1914. This latter was largely due to the teaching of Colonel Grandmaison just before the Great War. The writer sets out clearly and in an interesting manner the unsound bases on which this doctrine was built up, and the return to sanity of 1914-18.

The second and final instalment of Commandant Janssen's interesting article, "*La manœuvre en automobile*," is devoted to a description of an actual manœuvre carried out by a mechanicalised division. The protective measures taken, the principles on which the movement was based, and the actual manœuvre, are considered in turn. Unfortunately, the manœuvre was confined to a move without fighting occurring, but as far as it goes, it makes an instructive study. Two interesting points are,

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the provision of a Chief Transport Officer working directly under the commander of each column and the writer's suggestion that the infiltration of small mechanicalised bodies through the protective screen, is one of the chief dangers to be faced in a move of this description.

December, 1926.—"*Les trois glorieuses*," by Lieutenant-Colonel Doumenc, is a description of the three days' riots in Paris, known by the title name of the article, on July 27th, 28th and 29th, 1830. The author's object is to discuss the military aspect of the disturbances and to show how Marshal Marmont, who was placed in command of the troops at first, failed to control the populace owing to his neglect of military principles, which should be applied to the quelling of civil unrest, as well as to any other form of operation. The first instalment describes the inertia of the King and Dauphin at the beginning of the riots, and Marshal Marmont's unwillingness to act on his own initiative. The problem of action in the event of riot is one that is always liable to confront the soldier, and this description of a very important example makes interesting reading.

The third instalment of Lieutenant-Colonel Baills' article, "*Evolution des idées sur l'emploi tactique de l'organisation du terrain, de Napoléon à nos jours*," deals with the employment of engineers in the attack. The writer takes as his text the following quotation from the writings of Napoleon:—"Field works are always useful, never harmful, often indispensable," and he goes on to show how engineers can be employed on engineer work during the different stages of an offensive action. The general principles of employment coincide with those in force in our own army.

General Camon's article, "*Pour apprendre l'art de la guerre*," is written to prove, if further proof is required, that the study of the campaigns of the great captains is an essential part of the training of a commander. He goes on to suggest that the best method of study is to select a certain type of operation (*e.g.*, an attack against the enemy's rear organisation) and to study it in detail. Examples of this type of operation in a number of campaigns, including the Great War, are then given as illustrations.

In this number Lieutenant-Colonel Laure begins a series of articles entitled, "*Les étapes de guerre d'une division d'infanterie*." The writer's object is to describe the various stages through which the French division passed during the Great War, from 54 strong infantry companies with few mechanical weapons, in 1914, to 27 weak companies but strongly supported by mechanical weapons, in 1918. The writer takes the 13th Division as his model, and in this instalment describes in great detail operations from the outbreak of war to September 2nd, 1914, followed by a series of comments. Some of the latter are instructive, but a detailed account of operations of a single division is generally of interest only to those who have actually served with the formation concerned.

In "*Le salon de l'Automobile en* 1926," "X" gives a brief description of the French Motor Show and ends with a few criticisms of the administration of the money obtained by motor taxation. Apparently the "Road Fund," as known in England, is still a pious hope in France; however, the development of motor transport can be gauged from the

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fact that there are only forty-four very decrepit horse cabs in Paris now, as compared to twelve thousand in 1900 !

H.A.J.P.

REVUE DU GENIE.

(*January*, 1927.)—*The French Congo.* A description of the general condition and of the communications in French and Belgian Congo—of the railway under construction from Stanley Pool to the Coast, and of a Belgian scheme for canalizing the lower Congo and using the river for hydro-electric plant.

Destruction of Communication. (*continued*). Enumerates the repairs to railways, canals and roads after the Armistice.

(*February*, 1927.)—*The Work of the Engineers in Morocco in* 1925. Summarises the number of works of various descriptions, including Signal communications, executed or constructed.

The variation of personnel from month to month, numbers, animals and tonnage transported by military railways, and length of line constructed.

Navigation of the Lower Congo. Further details of the project described in January, calculation for flow of water and scheme for progress of works proposed, involving cost of three million pounds and thirteen years, concluding with a series of replies to possible criticism.

BULLETIN BELGE DES SCIENCES MILITAIRES.

(1926. TOME. II. NOS. 4—6 INCLUSIVE).

Les Opérations de l'Armée Belge (1914—1918.) The movements of the Belgian Field Army on October 10, 11 and 12, during the retreat to the line of the Yser, are dealt with in the three numbers of the *Bulletin* under notice. The Belgian G.Q.G. was now already established at Ostend. During the night of October 9-10, the dismounted troops of the 3rd, 4th, 5th and 6th Divisions were entrained and conveyed westward, the rear-guard duties being entrusted to the Cavalry Division, the 2nd Division and a mixed force under General Clooten during this move ; the British force under Rawlinson and the French troops under Ronarc'h were at this time in the neighbourhood of Ghent. By the evening of the 10th, the Belgian formations had safely reached the localities to which they had been ordered ; the 3rd and 5th Divisions (less the 20th Mixed Brigade) were now on the line of the Yser—the former at Nieuport and the latter at Dixmude—the 4th Division was at Ghistelles and the 6th Division and the 20th Mixed Brigade were at Thourout. Incessant fighting and the retreat from Antwerp had sorely tried the Belgian Field Army and it was, in consequence, in need of rest in order that the men might recuperate and an opportunity might be created for reorganising the Army for its fresh effort. However, a considerable force of German

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cavalry was reported at this time to be in the neighbourhood, and southward, of Ypres—the German 4th Cavalry Corps had on the previous day been reported as being south of Hazebrouck. In these circumstances, King Albert held a conference at Ostend at 2 p.m. on the 10th; General Pau was present as the representative of the French High Command and Rawlinson also attended. His Majesty wished carefully to examine into the situation with a view to ascertaining exactly the dispositions of the forces of the Allies, in order that he might decide upon a region wherein his Army could with safety be rested and reorganised. At the conference the King expressed a strong desire that the Belgian troops should, as far as possible, fight in their own country; eventually, owing to the representations of Pau, it was agreed that the Belgians should retire to the S.W. of the line St. Omer—Calais; no date was fixed for the move, but it was agreed that the British and French troops (under Rawlinson and Ronarc'h respectively) should maintain their positions in the neighbourhood of Ghent until the 12th. The Germans carried out a reconnaissance in force on the evening of the 10th and ran into the part of the line near Ghent, held by the Anglo-French force; Gontrode fell, for a second time within 48 hours, temporarily into the enemy's hands, but General Clooten quickly organised a counter-attack and won back the position which had been lost. Orders were issued on the 11th for the move of the Belgian Army into France as agreed at the conference of the previous day (see No. 5 at p. 463.) At the time these orders were framed the concentration of a considerable Anglo-French force was in progress in the region Arras-St. Omer with a view to an offensive stroke against the German Right Wing; Joffre wished the Belgians to throw in their weight in this attack. On learning of the decision to withdraw the Belgian Army into France, Joffre immediately telegraphed to Pau disapproving this move and suggesting that the Belgians should concentrate in the region Ypres—Poperinghe; at the same time, Pau was directed to get immediately into touch with Foch. Certain negotiations ensued and, an agreement having been arrived between the French and Belgian High Commands, the orders for the retreat of the Belgian Army into France were cancelled; Dunkirk was now chosen as the new base and the region Furnes-Nieuport-Dixmude as the new concentration area for King Albert's Field Army (see No. 6.)

La vérité sur la défense Namur en 1914. The second and third parts of the article under this title by Colonel Merzbach and Captain-Commandant Herbiet are published in Nos. 4 and 6; in the former number an examination is made of the secret report prepared by the Germans in 1915 in relation to their artillery bombardment directed against the Namur forts, and in the latter number a critical examination is made of the series of articles by M. Jean Fleurier published in the *Revue Militaire Suisse* during the period October 1923 to July 1925.

Des rapports entre le Gouvernement et le Commandement. The second part of Captain-Commandant Dendal's article on this subject is published in No. 4; it consists to a large extent of a review of the relations which existed in France during the Great War between the Civil Government and the French High Command. The subject is of immense importance to all soldiers and as treated in the original article will prove of great

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interest to them and possibly may help them to fashion their own conduct when holding positions of high responsibility.

La contre-préparation. In the original article, published in No. 4, Lieut.-Colonel Willemaers sets out the Belgian, French and German views as to the counter-measures to be adopted to meet an attack which may be immediately impending. The doctrines in relation to this subject contained in official books of instructions are examined and attention is called to the experiences of the Great War which provide practical illustrations of the manner in which the situation was met in given circumstances.

Le vide du champ de bataille. The second part of Captain-Commandant Menzel's article under this title is published in No. 4; it deals with camouflage as practised in the Great War.

La bataille de Mons. Major van Egroo's article on this subject is continued in No. 5; the situation on the British front on August 24, 1914, and the German movements on the same day are dealt with.

La traction électrique. In the original article, which is published in No. 5, Captain-Commandant Collet deals with the progress which is being made in certain foreign countries in the use of electricity as the motive power for ordinary road transportation; he also compares the *daily cost*—on the basis of a journey of 20 km. per diem—of maintaining and running certain types of vehicle. According to the tables in the original article the *daily costs* work out in Belgium—on the assumed journey of 20 km. per diem—at fr. 22.01 in the case of a two-horse vehicle; fr. 21.50 in the case of a 2-ton lorry run on motor spirit; and fr. 18.705 in the case of a 2-ton lorry equipped with electric batteries. Captain Commandant Collet finally sums up the advantages of electrically driven vehicles.

La fortification permanente dans la défense du Pays. The original article is the first part of a contribution by Major Deguent and is published in No. 6; therein attention is called to recent Press announcements stating that permanent fortifications are being constructed at Königsberg. Under the old regime, Königsberg was looked upon as the *réduit* of East Prussia and had for many decades been provided with permanent fortifications; the Treaty of Versailles decreed the dismantlement of the old defences. Although, in the early days of the Great War, permanent fortifications became somewhat discredited, owing to the comparatively short duration of the stands made by the defenders at Liège, Namur and Antwerp, the pendulum has already begun to swing again, and a reaction in favour of permanent fortifications is now in progress and contributions on the subject were published in 1926, from General Normand in the *Revue des Deux Mondes* and from General Nudant in the *Temps*. The following matters are dealt with in the original article: the defence system of Belgium in 1914; the rôle of the Belgian fortresses in 1914: the defence system on the northern and north-eastern frontiers of France in 1914; the rôle of the French fortresses during the Great War. A map accompanies the article and thereon are marked the principal Belgian, French and German defences on the Western Front of the Great War.

W.A.J.O'M.

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HEERESTECHNIK.

(*August*, 1926). *A Military Railway in Poland*, 1914, by Major Kretzschmann, ret. This is a sad story, but instructive! When, in Nov., 1914, the 9th German Army was advancing into Poland the existing railway system was found to be inadequate for those troops on the German left whose function it was to advance S.E. against the Russian right. To serve this flanking movement there was only a single line of railway on the left bank of, and parallel to, the Vistula. This line ran from just S. of Thorn to Lowicz, N.E. of Lodz, and lay rather far out on the German left. This fact, together with an exaggerated account of the damage done to it by the 9th Army itself when retiring over the same ground in October, contributed to a decision on the part of Army H.Q. to replace it by means of a light (60 cm.) military railway to be built parallel to it, but from 12 to 36 km. nearer to the centre line of advance.

The route was reconnoitred by an officer of Railway Troops on Nov. 11th, and it was decided that the line should run from the sugar factory at Montwy, into which the broad gauge ran, along 20 k.m. of a 75 c.m. gauge line, used for bringing beet-roots into the factory, and thence to Strykow (on the main-line, between Lodz and Warsaw), a total distance of 160 k.m.

On Nov. 12th, orders were given for the railway to be made, and the next day work started on the station-buildings at Montwy and on the conversion of the beet-root line. On Nov. 14th, the first train-load of railway material arrived at Montwy and the new construction started from the end of the beet-root line. When 30 k.m. of the line were in working order, Army H.Q. ordered the line to be used for supplies. First one station and then another was prepared as rail-head, but the supplies were not taken over by the troops. The trains stood unloaded for days in the stations, blocked the line and hindered the work. Thus, trucks which were required for sending up railway material were not available. On Nov. 25th, for the first time, supplies were taken over from the trains by the supply-columns. By Nov. 29th, the halfway point was reached (i.e., 60 k.m. of new construction in 15 days), and on Dec. 30th the line was completed to the terminus Strykow (i.e., 31 days for the last 80 k.m.). Neither the rate of progress in building nor the carrying capacity of the line satisfied Army H.Q. The chief reason lay in the over-hasty use of the line for supplies, since if both construction and the carriage of supplies have to take place simultaneously, it is natural that both must suffer. In November, an average of 200 tons of supplies were carried daily. This figure rose to 560 tons later, but even this total is not very satisfactory considering that 14 Railway Companies, comprising over 4,000 of all ranks, were employed. Up to a distance of 50 k.m. the country was almost level, so that gradients and curves were easy. Beyond 50 km. a very hilly country, with many swamps and bogs, made matters more difficult, especially as the rate at which the line had to be pushed on prevented the necessary care from being taken, so that in this sector there were frequent cases of sharp curves and steep gradients coinciding. In one place, indeed, it was necessary to divide the trains, four trucks being taken instead of eight.

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To hurry the work on, ballast was dispensed with, the sleepers being subsequently packed with earth from the spot. In the dry weather which prevailed at the start this proceeding caused no difficulties of any sort: the line was firm and safe for traffic. But all this was changed in a moment when the thaw came. Many of the low-lying parts now turned out to be swampy, the track was in many places flooded, and in others sank into the mud, causing numerous interruptions of traffic and often very bad derailments. Generally, they were obliged at first to leave derailed locomotives where they lay and to put in a new portion of line. There was no idea of keeping to a time-table. The circulation of trucks was irregular, many stations were overcrowded. Thus, on Nov. 25th there was a complete stoppage of the whole line, in order to clear which on the two following days sectors had to be closed. Since, owing to these numerous interruptions of traffic, the train-personnel were often on duty for 72 hours consecutively, the percentage of sick rose extraordinarily high. Also very high demands were made upon the railway troops engaged on the line, who were continually exposed to the worst weather and were accommodated under the most unfavourable conditions. In order to keep the line going at all, the whole of the available personnel had to be used on maintenance. At first an attempt was made to improve the worst places by means of pickets, planks and heaps of logs, but the success achieved was meagre, and it soon became evident that the only method was to remove the water-logged soil and to put down a regular bed of gravel 12ins. deep. Fortunately gravel-pits were available along the line, and were joined up to it by sidings.

At the same time the drainage of the entire line, which had been almost completely neglected in favour of rapid construction, had to be undertaken; but much time and labour were expended before it became effective.

After the thaw in December there came at the beginning of January heavy snow-storms, which caused extensive snow-drifts along the whole line, and on the 4th of January, caused a complete stoppage of traffic. All attempts to clear the line by means of snow-ploughs failed, and traffic was restored only after the snow-fall had diminished and by great exertions with the aid of additional working-parties.

Since, owing to the rapid construction, it had not been possible to provide watering-stations with high tanks, the boilers had to be filled from the numerous streams and water-holes. All went well until the heavy frost came, when much time was lost by breaking up the ice, and finally the shallow ponds failed entirely as a source of supply.

Owing to the combined effects of bad weather and bad track, the demands upon locomotives were very high. As at first there were neither sheds for shelter nor workshops for repairs, the number of locomotives out of action rose to 35 per cent. in the middle of January.

To sum up, the light railway did not come up to expectations because of exaggerated ideas concerning speed of construction and simplicity in running.

It was not realized that a light railway, if it is to do good service, can no more than any other railway be hurried on with to the neglect of careful choice of route, proper earth-work and ballast.

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In mobile warfare light railway construction should be confined to those few cases in which no broad-gauge lines exist. In this case all resources should have been concentrated on repairing the existing broad-gauge railway, an undertaking which would in far less time have provided an efficient and reliable line of communication.

F.A.I.

MILITARWISSENSCHAFTLICHE UND TECHNISCHE MITTEILUNGEN.

November and December, 1926.—*Wireless Picture-Transference and Wireless Vision for Military Purposes*, by Dr. Bandat.

A demand for an apparatus for transmitting pictures by wireless from aeroplanes was made in the German Army during the war, and experiments to that end were set in motion. The scientist who was charged with satisfying the demand then made, has now applied his experience to a simpler task, viz., the wireless broad-casting of weather-charts. This is done by the Bavarian Government Meteorological Observatory. At the appropriate hour the subscriber switches aerial from broadcasting-receiver to picture-receiver and sets reception-cylinder revolving. The movements of the pencil on the cylinder are guided by the modulations of the wave sent out by the Observatory. It is a long, long way to Wireless Vision; but the author considers, "no longer Utopian," self-flying bombers with electric eyes, being steered and made to drop bombs by reason of the pictures they send back!

Technical Formations and their Equipment, by Col. Schneck. In the Austrian Army there was before the War an Engineer Company to every Infantry Division; a Pioneer Company to every Infantry Brigade, and a Pioneer Troop to every Cavalry Brigade. There was also a small number of Pioneer, Bridging and Railway Companies outside the Divisions. The war equipment consisted of the portable and transportable equipment of the companies, of the divisional entrenching-tool column, of the bridging trains, and, finally, of a number of Parks (mobile tool depots, pioneer material depots, engineer siege parks). Long-handled intrenching tools, forestry implements, requirements for demolitions, and a certain quantity of barbed wire, completed the sum total of the equipment. As regards technical training, little value has been placed upon it by the fighting arms.

The mobile warfare in the first months of the war already showed that the existing technical formations and means were insufficient. When, however, the war became one of position, the demands on technical formations and the demands for technical aids of the most widely differing kinds rose immensely, especially when it became a question of reducing by technical means the enemy's superiority in numbers and material, and thereby saving man-power. This brought about on the part of the commanders much activity of organization and improvisation. A large number of special technical formations for the most widely differing purposes was created, of which only the most important can be mentioned, companies for telferage-lines, electrical, rock-borer, search-light and

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flame-thrower formations, building companies, labour companies and prisoner-of-war working parties. Also the reorganization of the Engineer arm was undertaken, but not completely carried out. Every division was to have a complete battalion of Engineers, of 3 Companies with 12 vehicles each as technical train, and a Divisional Engineer Train of 37 vehicles, and in addition to have allotted to it a number of building companies, so as to be capable of initiating even works of some size. Since, owing to the small number of wagons available, a general increase of issue to divisions of tools, building-materials and material for obstacles was not possible, each division received instead an Engineer echelon, containing workshops, and variously equipped according to the theatre of war and to the state of operations.

At the end of the War the number of technical and labour formations had risen to 3,400, nearly as many as the number of fighting formations, and there was roughly one workman to every rifle. Even with this apparently great number of workers, the incalculable amount of technical work could hardly be tackled, and the fighting troops could with difficulty be relieved from being called upon to furnish working parties—a duty so damaging to their fighting powers and spirit.

The collapse of the Central Powers and the Peace Treaty stopped all further development in this direction ; but a war of the future will make still greater demands on the technical formations than heretofore. Since the training of the pioneers necessitates about double the time of that of the infantry, the pioneers and all special formations should at least be prepared in peace to such an extent that their training and equipment can be brought quickly to the pitch indispensable for the defence of their country. Preparation for war should include, as regards personnel, arrangements for all specialists, and especially of the directing staff in all branches. Technicians cannot be dispensed with ; their lack is bitterly revenged upon the troops.

As regards material, the army authorities must keep constantly in touch with industry in order to have at their disposal in the requisite quantities the most modern types according to the latest advance of technics. The equipment of technical formations must be placed upon a new basis. Whereas the Army used to have at its disposal a sufficient number of technicians and of workmen generally, as a consequence of progressing industrialization the replacement of capable technicians has become difficult ; also labour must be spared more than ever. This compels the greatest possible replacement of men by machines, the widest possible standardization, and, as in industry, the economic use of labour on scientific principles. The farthest reaching use of mechanical, especially of electrical, power is the key to this. Electro-pneumatic rams, cranes, circular and band saws, boring-machines for wood and iron, tree-fellers and concrete-mixers, are only some examples. The creation of simple standard patterns for the different technical branches, where feasible their production in series, will simplify issue and replacement. Otherwise it will hardly be possible for the officer, let alone the man, to master the different branches of technics. There is now no longer a place for any but the simplest types, however theoretically justified. This does not imply,

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however, the exclusion of individuality. The engineer will still find he has a man's work to do in war, side by side with the other arms.

The World War first opened the eyes of many in all armies to the epoch-making signification of technics and industry to the conduct of modern war. Tactics and technics are indissolubly connected. The French War Minister recently said, " I am principally concerned in creating close co-operation between science and the army, and, indeed, of such a nature that every invention shall be used for increasing our national security. Similarly must industry and finance be introduced in peace to the rôle they have to play in war."

F.A.I

CORRESPONDENCE.

SHELL FIRE V. PERMANENT FORTIFICATION.

To the Editor of the *R.E. Journal.*

SIR,

In the December, 1926, number of the *Journal* there was an interesting article by Lieutenant H. B. Harrison, R.E., on Verdun and its Forts in the Great War. He brings out the fact that the forts as a whole resisted in a wonderful way the tremendous bombardment to which they were subjected. Then he goes on to make the conclusion that Verdun showed what a valuable asset to the field armies permanent fortification (evidently of the Verdun type) can be.

But is not this conclusion based on a very slender foundation ? We know that at the outset of the battle the forts had been disarmed and that they were only very partially re-armed during the struggle, so that they were practically passive shelters. What one would like to know, before forming any conclusion on their real worth, is what effect had these forts on the main struggle, as forts and not merely as shelters ?

Until this can be ascertained it seems hazardous to base a theory for defence works founded on such very expensive structures as these forts were, or similar works would be. Lieutenant Harrison rightly sums up the situation in saying that " the permanent fortification of the future will be but the deliberate application of the principles of field defences as established during the Great War." But this does not imply the necessity for the construction of the type of work of which the forts at Verdun were examples.

It is somewhat sweeping to say that the War witnessed a complete change of opinion as to the value of permanent fortification. The above quoted summary as to the fortification of the future is very much the same as the conclusions that many had reached before the War. The French General Langlais used almost the same words a number of years before 1914.

I am, yours obediently,

J. C. Matheson, Colonel (retired).

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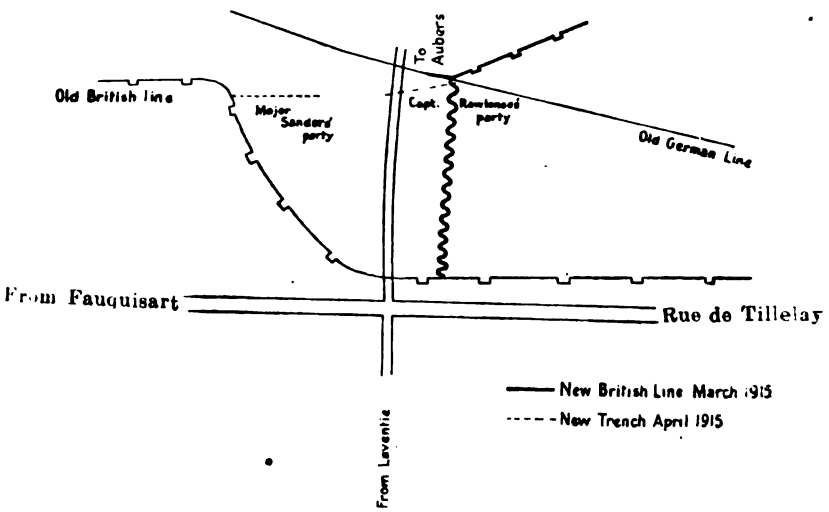
20th (FIELD) COMPANY ROYAL BOMBAY S. AND M.

DEAR SIR,—It is with some diffidence that I write to supplement the very excellent history of the 20th (Field) Coy., Royal Bombay Sappers and Miners, by Major H. W. R. Hamilton, D.S.O., M.C., R.E., but one or two episodes require correction or expansion.

April, 1915.—(Page 555, *R.E.J.*, December, 1927). The Company was employed during the whole of the period spent at La Flinque on the closing of the re-entrant mentioned, and the work was still incomplete when we handed over to the Sappers of the Meerut Division, on April 13th. The re-entrant was about 400 yds. by 400 yds., and was created by the Neuve Chapelle advance in March. Thus:



On the right we were in the old German front line, and about 30 yds. from the enemy. On the left there was about 100 yds. of old "No Man's Land." Down the centre of the re-entrant ran the flooded road from Laventie to Aubers. We attempted to complete the task in one night. On the right I had a party of infantry and two sections of sappers to bridge the flooded road, build a barricade and make drains. We got to work at dusk, and were well started when Major Sanders with Major Cumings' Company of the 12th Pioneers (attached 34th Pioneers), and a few sappers started out from the left. They had been delayed by ration parties. Although further from the enemy than my party, they were spotted immediately, and of the 60 men who got on to work about one-third were killed and wounded within a few minutes. They stuck to it, however, with great gallantry, and completed about a third of their task. Casualties on the right were few, as the men already had some cover. I personally spent a very unpleasant half-hour between the two groups, having been across to see Major Sanders, and re-align the tape, which the Manchesters, holding the line, reported moved by a German patrol. It was for this night's work that the thanks of the G.O.C. Division were received; and thereafter work proceeded almost entirely by sapping, other progress being impossible.

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2nd Battle of Ypres, 1915 (see plan opposite page 560, December *R.E.J.*). The right half company under my command got through to La Brique with very few casualties, as we were ahead of the shelling. April 26th was spent in the valley south of La Brique, making Brigade H.Q. Signal and dressing station dugouts. An attack by the 9th Sirhind Brigade was ordered for the night of April 26-27, the right half company to follow for consolidation. The Brigade received orders to halt in the valley S.E. of French Farm, and eventually the attack was counter-ordered about midnight. After reconnaisance with Captain Kisch, of 21st (Field) Company, the half company spent the rest of the night consolidating French Farm, assisted by Major Cuming's Company of the 34th Pioneers. The Sikh section suffered considerably from lachrymatory shells. Sapper Dateh Singh, I.O.M., of Neuve Chapelle, 1914, then a Naik, was hit in the lungs, and finally left the company. Havildar Uttam Singh, commanding the section, obtained the I.O.M. for this night's work. On the afternoon of the 27th, the 7th Ferozepore Brigade was ordered to attack N.E. with its left on "Moated Grange." The half company and the Pioneers remained at La Brique, and it was there that Capt. K. Mason was wounded. I remained with Brigade H.Q. in "Defensible Farm," whence a panorama of the attack was obtainable. At dusk I was able to reconnoitre the whole ground covered by the attack without hearing a shot fired. Night work on consolidation of the ground won was, however, much delayed by the difficulty of getting orders, and work was not started till after midnight. During the night of 27-28th I received orders to take over command of 21st (Field) Company as from April 26th, and left this gallant company early on the morning of the 28th, and not on the 26th, as stated.

The operations at Ypres were full of lessons for Sappers. The attacks of the Lahore Division took place across the open through a gap between the French right at "French Farm" and the British left, east of "Moated Grange." The advance was down a glacis slope, across a marshy valley, and up a slightly convex rise.

The ground was devoid of features involving special tasks for Sappers There was little for Sappers and Pioneers to do by day, and three-quarters of their heavy casualties would have been saved had they been left west of Ypres. Reconnaisance by advanced Sapper parties at dusk was extraordinarily easy, and without risk. As the light failed a complete hush spread over the country. On the other hand, although Sappers, Pioneers and material were available, and detailed reconnaisances completed shortly after dusk, it was seldom possible to start work till early morning, owing to lack of orders. On the nights of both 26-27 and 27-28 orders were only obtained after a brigade conference had been arranged. As a detail, all messages between the advanced party and the unit should be duplicated and sent by two stout-hearted orderlies at not less than 200 yards distance. Casualties to orderlies in this heavily-shelled area were very severe.

In conclusion, the trench, H-C-K. was completed at night with only a dozen or so casualties, and was within a few yards of the furthest

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limits reached by the day attacks, of which the cost was a loss of several thousand.

Yours truly,
M. RAWLENCE.

DIVISIONAL ENGINEERS.

To the EDITOR, *R.E. Journal.*

DEAR SIR,—In connection with General Walker's article on Divisional Engineers of the Future it may be of interest to know what is being done as regards mechanizing the 17th Field Company. The vehicle decided on for this unit is the 1-ton Morris six-wheel lorry with the standard W.D. body. The lorry will carry 14 men, including the driver; the tool cart and one L.G.S. wagon are each replaced by one lorry, and in the case of the tool cart, the tools are packed in boxes which fit on and between the seats; in this way one standard type of lorry serves both for carrying the men and the tools and equipment. Owing to financial stringency, it will not be possible at present to allot a full scale of these cross-country vehicles to the unit, but at war strength the section might, perhaps, consist of 6 lorries, *i.e.*, 4 to carry men and the remaining 2 for the tool cart and L.G.S. wagon. In addition, there would be required lorries for company headquarters carrying the personnel, technical tools and stores, water cart and travelling kitchen, etc. These lorries can travel across country almost anywhere, and they can surmount the most surprising obstacles. Generally speaking, they can go anywhere that horse transport could go, and negotiate some ground that would be impassable to the ordinary field company horse transport. In addition they can travel fast and economically on the roads. By having six vehicles for one section, the men could disperse in small parties with tools and explosives, and it would appear that these vehicles should serve very well for the trials that will be carried out this summer.

From the point of view of the 17th Field Company, these trials will be of a dual nature. The primary object in mechanizing the 17th Field Company is to enable it to work with the experimental mechanical force on Salisbury Plain. For this purpose, the question of the equipment to be carried, the amount of explosives necessary, and the special bridging equipment required, will all have to be considered in detail. Much experience should be gained during these trials, and special vehicles for bridging will be added to the unit in due course. At the same time the unit still remains a field company in the 3rd Division, and experiments will be carried out to determine the best way of carrying the normal tools and equipment of a field company in these lorries; much experience will be gained and will be available, if it should be decided in the future to mechanise the field companies of the expeditionary force.

In both cases the points raised by General Walker are of great interest. The question of using mechanical power in this way is not entirely new. In the October, 1920, number of the *R.E. Journal*, will be found an account and photos of some work of this nature which was carried out at Christchurch just after the war. At that time, however, the whole army was still imbued with the spirit of trench warfare.

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The weapon of mechanical warfare was the heavy tank, and it was, therefore, the heavy tank that was considered in connection with the mechanized field company for work with a mechanical force. A complete organisation was worked out, based on the use of four heavy tanks per section. The tanks were used like very strong bullet-proof elephants, to assist with bridging—gaps from 20 feet to 70 feet could be bridged to take the heaviest tanks in a few minutes—and the work could be done under fire. The tanks were also used for mine sweeping, clearing away obstacles such as demolished bridges, carrying forward demolition charges under fire, and later they were used for cable burying and trench ploughing. Very soon after the war, however, the heavy tank became obsolete, and the question of using mechanical power to assist an R.E. field unit required reconsideration. Financial stringency, however, made it difficult to carry on this work, and the whole question has lapsed until quite recently.

General Walker referred to the possibility of using mechanical power under nine headings, as follows :—

(*a*). Reconnaissance.
(*b*). Clearances of fields of fire.
(*c*). Obstacles.
(*d*). Preparation of elaborate defences in stabilised positions.
(*e*). Bridging.
(*f*). Demolitions.
(*g*). Water supply.
(*h*). Protection against weather.
(*k*). Communications.

Some of these affect a field company working with an infantry division only ; others apply equally to a field company working with a mechanised force. I do not propose in this letter to consider the question of bridging at all ; it is a very complicated subject at the moment, and is under consideration at the War Office ; many new devices have been produced recently—mechanical and otherwise—and the subject would require a whole article to itself. As regards the remaining eight points raised by General Walker, (*c*), (*f*), and (*g*) are the only ones which will seriously affect an R.E. unit working with a mechanical force. In any case, however, I would suggest that the eight points should be divided into two classes as follows :—

Class I.—Those which are required to be carried out at short notice with the equipment belonging to the unit.

Class II.—Those for which special preparations have to be made, such as the sending up of material from the rear, and which cannot in any case be carried out at short notice.

Of these, (*a*), (*b*), (*c*), (*f*), (*g*), belong to Class I, and (*d*), (*h*), (*k*) belong, generally speaking, to Class II. With Class I, anything which we can carry, which will assist us by mechanical means to expedite the work or increase the output of the unit, should form part of the normal equipment.

On the other hand, with Class II, it will usually be better to send up any necessary mechanical appliances which may be required, from R.E. Parks in rear, when it has been decided that some work of this nature is to be carried out.

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Coming down to details, the only proposals that have so far been made for gaining assistance from mechanical power are as follows :—

(*a*). The lorries—or at least one lorry per section—should have a pulley, or some means of power to take off from the engine. This would be used when required to drive a rotary pump for a temporary water supply and any other purposes of this nature.

(*b*). A proportion of the lorries should be fitted with a winding gear, and possibly a light derrick ; this would facilitate many operations which have to be carried out by the Royal Engineers in the field.

Both the above accessories have already been asked for, and will represent a certain advance in the right direction ; in addition, the question was raised about two years ago of a portable compressor plant for use in the field—particulary for rapid pile driving, and for any other work, such as drilling. The question was considered by the R.E. Board, and there were certain technical difficulties, but with the advent of a mechanised field company the question will no doubt be reconsidered. General Walker has, however, raised many other points which have not yet received much consideration, and any suggested solutions will be awaited with interest.

Finally, it is not unlikely that the mechanical force will eventually take the form of a force moving in nothing but armoured vehicles, so that the whole force will be bullet-proof. In this case the field company would also move in armoured cross-country vehicles, and the ideas which were produced at Christchurch in 1919 would have to be re-invented ; the vehicle would have to be far lighter and more mobile than the Mark V tank, but the main duties would remain the same, namely, bridging, mine sweeping and demolitions. Our immediate problem, however, is to improve the efficiency of a field company equipped with six-wheel lorries by using mechanical power in the directions suggested by General Walker.

Yours faithfully,

G. LE Q. MARTEL,

Major, R.E.

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ARTHUR FFOLLIETT GARRETT PRIZE ESSAY, 1927.

Subject selected :—"Railway Work on Active Service."

The Essay should take the form of an appreciation of the Railway position and the railway problems to be met with in the circumstances outlined in the succeeding paras.

In it should be set forth fully the steps that would be taken to cope with the situation ; to facilitate prompt construction ; and to provide all necessary organization, staff, facilities, plant and stores to carry out construction and to ensure an adequate railway service.

(2). The Expeditionary Force consists of three Divisions and one Cavalry Division, with the normal proportion of non-divisional and L of C. units, also four Squadrons. R.A.F.

Included in the L. of C. units are :—

One Railway Survey Unit,
One Composite Railway Company,
Two Railway Platelaying Companies,
One Railway Bridging Company,
Two Railway Operating Companies,
One Railway Stores Company,
One Advanced Railway Workshops Company,
One Base Railway Workshops Company,
One Railway Telegraph Construction Company.
One Railway Telegraph Operating Station,
also One Dock Company :
all at Small War Establishment and with the several departmental headquarters.

It is probable that the E.F. will be reinforced by one Division.

(3). The Base, which has accommodation for 8 ships at a time and limited facilities for handling loads in excess of 12 tons, is a railway-served port in a friendly country which cannot undertake military operations outside its own borders.

(4). The railway, which is 4ft. 8½in. gauge and single throughout its length, runs 300 miles to the border of the hostile State, against which operations are to be undertaken, and has one 40-mile branch at Mile 30.

(5). The E.F. will require railway communication 450 miles from the coast, *i.e.*, 150 miles into the territory of the hostile State, which is without railways.

(6). The following further railway information and intelligence has been obtained :

i. Railway in friendly State owned and worked by local private Company,

ii. Normal train service :—
2 mixed trains and 4 goods trains per diem, each way, to mileage 200 ;
1 mixed train and 2 goods trains per diem, each way, between mileage 200 and the terminus at Mile 300 ;
1 mixed train per diem, each way, on the branch.

iii. Crossing sidings average 10 miles apart.

iv. Line operated on Telegraph and Paper Order System. Home and Outer Home signals at stations.

v. Goods trains maximum loadings :—
270 tons gross, mileage 0—200 and on the branch ;
600 tons gross, mileage 200—300.

vi. Rolling Stock :—
70 main line tender engines,
15 shunting engines,
3 10-ton (hand) cranes,
250 30-ton (bogie) trucks,
850 10-ton (four-wheeled) trucks,
80 passenger (bogie) coaches.

vii. 75 lb. rail ; wood sleepers, spaced 3ft. centres.

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viii. Ruling grades :—
1/40, mileage 0—200 and on the branch ;
1/100, mileage 200—300.

ix. Fuel (imported) coal.

x. Water plentiful, but loco. watering plant only sufficient for present train service.

xi. Loco. heavy repair shops at Base.

xii. Engine depots at mileages 0, 100, and 200.

xiii. Reserve of permanent way and other materials small.

xiv. Line poorly ballasted except between mileages 0—100 and 200—250.

(7). The enemy only partially trained, but mostly officered by Europeans, and having modern field artillery and aircraft and good anti-aircraft defence, has raided the friendly country for 50 miles and destroyed, or partially destroyed, the railway as far as mileage 250. At this point he is held by the forces of the friendly State, but cavalry raids have been made on the L. of C. as far back as mileage 200. The railway has been restored to mileage 240.

(8). At mileage 260 is a bridge of 8 spans of 100 ft. over a river not more than 200 ft. wide, with a maximum depth of 6ft., except in the flood season, when the river rises as much as 10ft. for short periods and is 600 ft. wide.
There are no other big bridges between mileages 240 and 300, but several small bridges, including some of 40 ft. and 50 ft. span.

(9). Maps of enemy State are inferior.
The country beyond the border of the friendly State is comparatively easy for the first 50 miles; for the next 50 miles it is more broken and gradually rising, probably necessitating some rock cutting and a ruling grade of 1/40 ; beyond this it is again comparatively easy.
There are three rivers to be bridged, one at the border, a mile beyond the terminus at mile 300, and the others at approximately 50 and 100 miles from the border. The rivers are comparatively small streams in the non-flood season, and are not more than 5 ft deep, but are liable to 10 ft floods and are 200 to 300 yards wide when in flood.
There is no surface water except from these three rivers. The villagers obtain their water from wells, but the yields are somewhat precarious except in the flood season.

(10). Operations start from railhead, mileage 240, early in December. The floods generally commence about mid-April and last till the end of June.

(11). The Commander of the E.F. anticipates but little serious resistance and has informed you, his assistant Director of Railways, that this progress will depend on the rapidity with which a railway L. of C. can be constructed and worked. He also informs you that the strength of the R.A.F. with the E.F. is slightly superior to that of the enemy Air Force.

(12). Roads are practically non-existent in the enemy territory, and such as there are will require much attention before even medium M.T. can be used, whilst there is no road metal nor ballast except between mileages 200 and 250 in the friendly State and from 50 to 80 miles from the border in the hostile State.

Essays must reach the office of the Secretary, Institution of R.E., Chatham, not later than the 30th NOVEMBER, 1927. Essays must not be signed but each essay must bear a pseudonym, and the name of the writer, enclosed in a sealed envelope marked with the same pseudonym, must be attached.

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2. Qualifications of the recipient : To be an officer on the Active List of the Royal Engineers, not above the substantive rank of Captain on 1st January, 1927.

3. The essay must not exceed **10,000** words.

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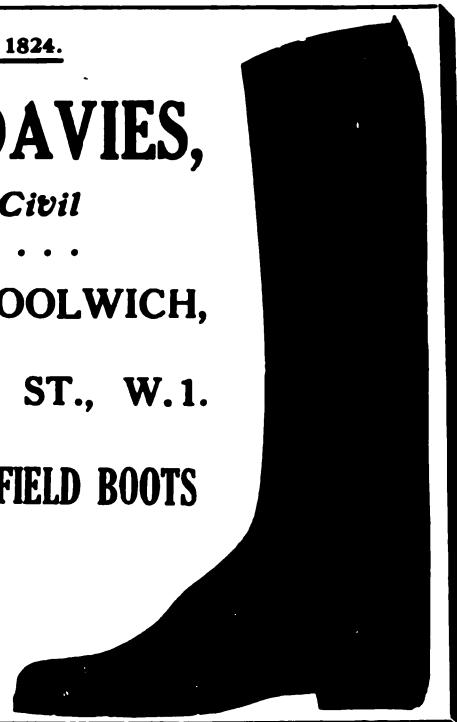

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Headmaster (since 1922), LIEUT.-COLONEL E. N. MOZLEY, D.S.O., R.E. (RET.).

SPECIAL TERMS TO OFFICERS.

Five Public School Scholarships gained since March, 1925, including two "Firsts" and one "Second."

In every case the boy was top in the Higher Mathematical Paper.

Good Health Record. School Farm. Riding, Swimming, and Special Outdoor interests.

PROSPECTUS ON APPLICATION.

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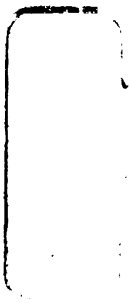

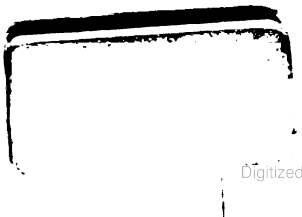

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